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THE SOUTHERN LUT AND IRANIAN BALUCHISTAN

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THE purpose of this journey was to explore more exactly than hitherto the deserts of Iran. By "Iran" I do not wish to be understood the State, but the large tract of Nearer Asia which lies between Elburz, the mountainous district of Khurasan, the heights of Paropamisus, the Turkistan Alps or the Hindukush in the north, and the chains of Farsistan, Baluchistan, and the steep, high ranges of the Suleiman mountains in the south. We wished to make use of the experiences we had gathered on our previous journeys and to amplify the results. As in the case of our first two expeditions, my wife and I made this one alone, without European companions.

The first journey was made in the years 1927–28. From the Persian Gulf we travelled into the mountainous country of Bashagird in southern Iran, where we succeeded in entering Anguran, the capital of the land. *Via* the Jaz Murian swamp we penetrated into the Lut, crossed the desert by new paths, and terminated our journey with an investigation of the great northern Iranian salt-swamps. As a result of this trip several white patches on the map could be filled in. Four years later we undertook our second journey. Several months were again spent in the salt-swamps of northern Iran, and this time the sand desert of the Rig-i-Jinn, the Desert of Ghosts, which borders the salt-swamps on the south, was also explored. We crossed the middle part of the Lut twice more, and then pushed on to the south into the Sarhad of Iranian Baluchistan. The goal of the third journey too was the dry wastes of the highlands of Iran.

We must distinguish two great belts of desert, which are separated by the east Persian mountains. These deserts have been formed by the piling up of the mountains bordering Iran, which constitute a barrier to the moist sea-winds. The one desert belt lies completely within the boundaries of the State of Iran. This belt begins immediately outside Tehran and stretches for over 600 miles right into the heart of Iranian Baluchistan. In the north the process of desert formation is less advanced and the former inland lakes are not yet

completely choked up by the debris of the surrounding mountains. Here the land consists of extensive *kawir* or salt-swamps. In the south, all the forces that combined to make a desert have had a stronger effect and have turned the what were once wet districts into dry, dusty, sandy wastes. The whole desert belt is called "Lut" by the inhabitants. The second desert belt lies partly in Iran, partly in Afghanistan, and partly in British Baluchistan. This belt also is in the north largely composed of *kawir* and extends from the Namakzar and Dak-i-Patargan desert across the Dasht-i-Naumid, the Desert without Hope, the Dasht-i-Margo, the Desert of Death, as far as Rigistan in the south-eastern corner of Afghanistan.

The first and most important task which we undertook on our third journey was the exploration of the southern Lut. There lay a tract of about 18,700 square miles, that is to say, of the size of Belgium, which had hitherto resisted all attempts at investigation. It was the lowest-lying and the hottest part of the Persian desert belt. This unknown territory was surrounded on all sides by wastes, the penetration of which was not an attractive undertaking. We had discovered on our two previous journeys that a sea of sand-dunes isolates the southern Lut in the east and south. Along the west runs the almost dried-up lake at the end of the Kal-Shur river, and since in the north the desert runs into still other dry wastes, and thus loses nothing of its inhospitable character, it was hardly possible to enter it from that side either.

In addition to the difficulties deriving from the absolute lack of water and vegetation in this territory, there was the terrible climate. During the winter the country is dominated by what is called the *Bad kessif*, "the dirty wind," a south wind which carries with it immense quantities of dust and sand, and completely destroys visibility. In summer there is instead a north wind which, as a result of having passed over hundreds of miles of burning desert, has become so dry that it absorbs all the moisture of every living organism. There is not a single bit of shade to give protection against the heat of the day. The geographer G. Stratil-Sauer, on the basis of his investigations, was of the opinion that the hottest region of the earth was not, as hitherto supposed, to be found in Sind, or Abyssinia, or in the Death Valley of California, but in the southern Lut. The mountain ranges which encircle the desert rise here and there in the south and south-west to more than 10,000 feet above the lowest point of the Lut. The hot winds from this direction become still hotter as they sweep down from the mountains, and thus the desert, already exposed to the burning rays of the sun, is subject to a heat such as is not to be experienced elsewhere.

We hoped that our expedition into this unknown territory would yield results for various branches of science. Nothing was known either about the surface formation or about the inner structure of the desert. It was uncertain as to what became of the rivers flowing into the Lut from the south. Old maps indicated a second great salt-lake in the heart of the desert, the Shurgaz Hamun, but it was doubtful whether it existed. There were also problems of historical geography to be solved. According to medieval geographers [1] there was once a route cutting across the whole breadth of this unexplored territory and leading from the south-west straight through the white patch

[1] Istakhri, pp. 229, 237 ('Bibliotheca Geographorum Arabicorum,' Vol. I).

on the map to Deh Salm. Since it can be assumed with some certainty that the climate of Iran has not changed for the worse in historical times, this route must, we thought, still be practicable.

All our previous attempts to penetrate into this desert had failed. At the end of our second journey we had conferred with Malik Shah Khan, the chief of the Naru'i Baluch tribe in Nasratabad (Sipi), on the possibility of crossing the southern Lut, and thus we returned at the beginning of 1937 with very definite plans. We intended to push forwards from the most advanced well in the north-east and cross the desert diagonally towards the little oasis of Keshit, more or less in the direction of the route indicated by the Arabian geographers. We wanted to begin our trip in the early spring, as at this season we might also find camel pastures on the edges of the desert. For the transport of water we had had special aluminium tanks made after the pattern of those used by Sir Aurel Stein. As guides we could use only men of the Baluch tribes, who, like the Badawin of Arabia, are very experienced in travelling through the deserts, who are moreover brave, and are not afraid of undertaking journeys even into unknown country. It was unfortunate that a complication arose between the two Baluchi tribes, the Naru'i and the Isma'ilze'i, which are the only two tribes inhabiting the southern and eastern border districts of the desert. Although the energetic Government of Shah Reza Pahlevi has done everything it can to pacify the Baluchi tribes, blood feuds between them cannot completely be abolished, and between the members of the tribe who accompanied us, the Naru'i, and the Isma'ilze'i, there was bitter enmity. A meeting with the latter would inevitably have led to bloodshed, and we were therefore anxious to avoid a collision.

The caravan was assembled in the last days of February 1937 in Fahrej, a small malaria-ridden village east of Bam. In order to reach Malik Shah Khan in Nasratabad, who was to provide us with new guides across the Lut, we chose a new route through the Zangi Ahmad desert of which E. Smith had heard sixty-five years ago. Up to the time of the Great War this path was used by Afghans for smuggling guns. The journey to Nasratabad, which took five days, brought us into close contact with the southern sands of the Lut. They lie in the direct path of the wind, and assume the character of drifting dunes which are constantly changing their form and shifting hither and thither. In these sands all life is extinct.

From Nasratabad we set out northwards on March 7. We kept as close as possible to the sand-dunes, which were unexpectedly high and extensive. The aspect of the eastern sand wastes is very different from that of the southern sands. The eastern sands consist of the older, more settled part of the dunes. The firmness of these masses of sand is shown by the fact that they are covered with vegetation. They evidently owe their size to the decreased force of the wind in this region, which only borders on its direct path. In some parts the dunes rise to imposing heights. One of them, which we climbed on March 13, was 620 feet high. Wherever we got a glimpse into this sea of dunes it extended westwards, southwards, and northwards as far as the eye could see, in a waste of giant waves sculptured in sand. Whole mountains of sand came into sight whose heights greatly surpassed those of the dunes which we had climbed, for they were in all probability more than

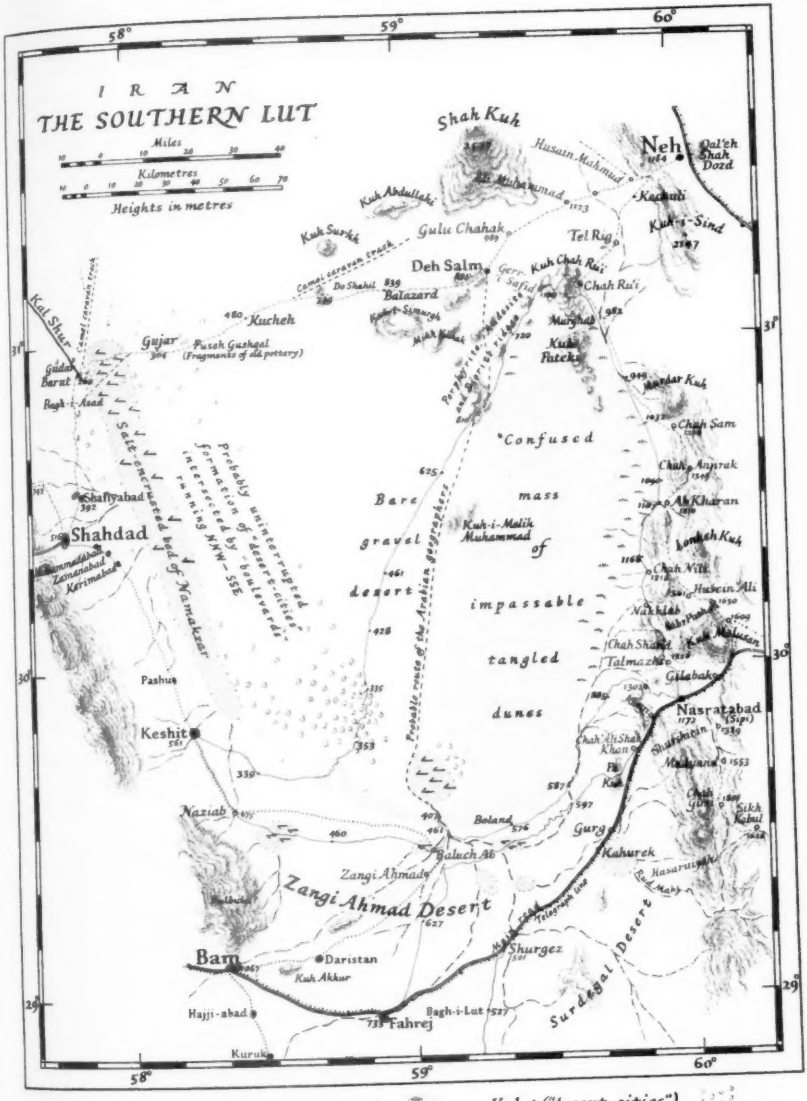
700 feet high. According to G. Rolland there are in the Sahara hills of sand 500 feet high. In the Lop Nor desert dunes with a height of 600 feet have been measured. But we should never have believed that sands existed such as those now lying before us if we had not seen them for ourselves. These enormous dunes of the southern Lut have been caused by a chaotic piling up of sand-drifts. The direction of the prevailing wind can be determined by observing which is the steep side of the dunes. The sand itself is patterned with patches of light, fine material and dark, coarser stuff. Broad hollows often separate these higher massifs of sand, which, according to what the natives say, do not change their position. It is principally the wind that has formed these depressions, at the bottom of which very often large quantities of fragmentary remains of organic matter are whirled round.

The vegetation consists almost only of bushes of *Haloxylon ammodendron* and *Calygonum polygonoides*, between which grow sparse bunches of grass. These plants often grow quite luxuriantly and, because of the moisture which is to be found a few feet below the surface, are still green at a time when the vegetation on the lower-lying steppes has long since withered. Above 300 feet vegetable life gets very scanty, and the tracks of animals too, principally small rodents and lizards, become scarce. The highest parts of the dunes consist only of shifting, virgin sand.

Very striking is a formation which is to be found in the sand waste from the neighbourhood of Ab Kharan northwards almost as far as the end of the dunes. Here the sands are cut off from the surrounding country by a high rampart, which is of a more or less uniform height, and the small dunes covering it look from the distance like the sand-ripples of the sea shore. This mighty wall of sand can only have been formed by the weakening of the wind velocity at the edge of the sea of dunes, where its borders run parallel with the prevailing wind direction.

We travelled for more than a week along the eastern edge of this sea of dunes, moving from well to well *via* Nakhlab, Chah-i-Nili, and Ab Kharan. The district has a thin population of Naru'i Baluchi, who live in black tents and wander with their camel herds from one source of water to another. The borderlands of the sand waste are excellent camel pastures, and the herdsmen often penetrate the dunes to a distance of two days' journey. In summer the sands get so hot that the soft hoofs of the camels are scorched. Such herdsmen are isolated from the world, and live for weeks on camel's milk alone. Bread is a rare delicacy. Dates, which are to be found on the western borders of the desert, do not grow at all in these eastern regions of the Lut.

On March 15 we reached the northern spurs of the sand-mountains. From here we intended to strike into the heart of the Lut. At Chah Ru'i, a well at the foot of a small mountainous mass of light granite, we halted for a few days to rest. Unfortunately the weather was not very promising. On March 16, 19, and 20 there raged violent storms of sand and dust, which we had to endure as best we could. Storms we considered to be the greatest danger that we should have to face on our coming journey across the desert. We were also worried by the surface formation of the country before us, for it seemed that ranges of hills as well as dunes lay across the direction of our march. But the most important thing was to avoid getting into salty swamps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THE SOUTHERN LUT
Miles
Kilometres
Heights in metres
Shah Kuh
Husain Mahmud
Kuh Abdullah
Kuh Surkh
Gulu Chahak
Tel Rig
Neh
Kal'eh Shah Dozd
Kuh-i-Sind
Deh Salm
Kuh Chah Ru'i
Chah Ru'i
Balazard
Kucheh
Gujar
Pusch Gushgal
(Fragments of old pottery)
Kal Shur
Kuh Patek
Murdar Kuh
Chah Sam
Chah Nimrak
Ab Kharan
Kuh-i-Malik Muhammad
Bare gravel desert
mass of impassable tangled dunes
Confused
Probable route of the Arabian geographers
Probably uninterrupted formation of "desert-cities" intersected by "boulevards" running NNW–SSE
Salt-encrusted bed of Namaksar
Shahdad
Shafiyabad
Muhammadabad
Zainabad
Kerimabad
Pashus
Keshit
Naziab
Baluch Ab
Boland
Gurg
Kahurek
Nasratabad
Gilabak
Talmazha
Chah Shaikh
Kuh Malusan
Chah Ali Shah Khan
Shafiabad
Chah Gurg
Sikh Kabul
Hasanuiyeh
Zangi Ahmad
Zangi Ahmad Desert
Bam
Daristan
Kuh Akhur
Hajji-abad
Fahrej
Bagh-i-Lut
Shurgez
Surdegal Desert
Kuruk
58°
59°
60°
29°
30°
31°
Sand
Sand with vegetation
Kalut ("desert-cities")
Salt-plains (Kawir)
Hard salt-crust
Hard salt-encrusting clay
Water places
Cultivation
Dr. Gabriel's routes
1928
1933
1937

in the low-lying parts of the desert. These swamps, and the deposits of the former Lut lake, which the elemental forces of the desert have chiselled into shapes having a fantastic resemblance to buildings (so that they are called by the Iranians *Shahr Lut*, desert cities, and by the Baluchis *Kalut*, desert villages) might have brought our expedition to a stop before we had reached our goal.

We were anxious as to how the camels would stand the journey. All the animals we had been able to get together were at that season none too strong, having just come from their winter pastures, and the spring pastures were disappointing. Inside the Lut the camels would have to feed entirely on the chopped straw and barley meal which we took with us. It was of course impossible to carry with us any water for them. It was fortunate that in the west of the Chah Ru'i mountains there was yet another source of water, although not a plentiful one, Gerr-i-safid. It was here that we waited for a favourable opportunity to begin our journey. We could not wait very long, as our stores were limited.

Throughout the night of March 20–21 a storm from the south-east swept over our exposed camp, but by morning the wind had dropped. We decided therefore to set out. The terrain was unexpectedly practicable. We were able to avoid the dunes, and the sharp tops and the hillocks of solid rock were buried deep in masses of debris, the surface of which was only slightly undulating. The ground was covered with fragments of flint, and its uneven surface was levelled out with clay having a hard upper layer of coarse sand. The whole scene was lifeless and forlorn. But fortune was not kind to us on our first day in the Lut. Early in the afternoon one of the most turbulent storms we had ever experienced sprang up. There was little sand in the wind, but a lot of dust, and the result was an imposing natural phenomenon. The landscape suddenly darkened under red clouds, then it grew gloomy, and a noise like the roaring of the sea began. The storm seized us with its full force. For several anxious hours we lay, motionless and helpless, outstretched on the ground. Most storms in Iran die down after sunset, but this one raged over us far into the night, and it was not until the dawn of the next day that we could continue our march.

From the summit of a low pass between two hills an archipelago of dark eminences could be made out. The sea of dunes, which we could now see for the first time from the west, reached right up to these hills, of which small spurs had been engulfed by the masses of sand. We kept on steadily between the hills on the right and the dunes on the left. The latter were as imposing as the dunes on the eastern side of the sand region. They were quite bare, except for a narrow border of vegetation at their foot. It was an unpleasant discovery for us when we came across traces of camel-dung. The natives must therefore have been quite right when they said that our desert track was used by Isma'ilze'i robbers, for in Iran there are no wild camels; freely grazing animals do not wander as far as this into the desert, and to caravans the path is unknown. Twenty-five miles beyond Gerr-i-safid even the most scanty vegetation ceased, and the desert stretched out before us as lifeless as the surface of the moon.

On the evening of March 22 we reached the boundary of the region of

volcanic rocks. There now lay before us, at a lower level, a perfectly flat stretch of country paved with stones. Just one single conspicuous mountain massif appeared at 30° west of south. We called this mountain Kuh-i-Malik Muhammad, because our guide Malik Muhammad said he had seen it years ago from the distance. It is a very noticeable landmark in the interior of the Lut. When we camped for the evening we discovered to our dismay that one of our water-tanks was leaking. We allowed ourselves only two hours' rest and then pushed on.

During the next few stages of our march we drew farther and farther away from the sea of dunes, which remained to the east. Progress was not difficult. There were no erosion channels in the ground and nothing to indicate water action. The surface of the land had been formed merely by the wind. The ground was perfectly flat and the terrain of a uniform character, covered with a dark residue such as is left after the wind has swept away the loose soil. We were very much handicapped by mirages. These were very vivid in the coldest hours of the day, just before sunrise. The cause of the phenomenon is the refraction of the light rays from the heavy, cold masses of air just over the ground which have cooled off considerably by radiation during the night. During the daytime the same reflections are to be seen when the relative density of the masses of air is reversed, that is to say, when there is a layer of thin, hot air just above the ground which has been superheated by the sun's rays.

Whenever visibility was at all good we had an extensive view of the sea of dunes, which looked like a real range of mountains, and of the Kuh-i-Malik Muhammad. The latter towered up massively from out of the steel-grey cone of detritus surrounding it, and was covered almost to its very peak with patches of sand. On the evening of March 23 we had come to the edge of a shallow shelf and could look out far to the south-west, where we supposed Keshit to be. Faint grey outlines could be seen just above the horizon, but we could not be sure whether they were clouds or mountains.

After another night march the dawn of the 24th offered us a fascinating spectacle. Far in the west lay a continuous yellow wall of even height, consisting of one wild range of hills behind another. These were the notorious Kalut. They barred our way to Keshit. Our prospects of getting farther were unfavourable, for we had to make a detour to the south in order to avoid the Kalut, and we wanted to push on without resting. But the camels went on strike. On this last stage they had already several times attempted to lie down, and so we had to let them halt for a while. After a few hours the march was continued. The sun burned down. The temperature of the air rose to 94° F. and our progress was slow. The sand waste was only just visible at a great distance in the east. We approached closer and closer to the Kalut wall, but did not reach it until the late afternoon. A narrow strip of *kawir* separated it from the firm, stony ground we had been crossing.

Apart from the tracts of salty clods in the heart of the Great Kawir in northern Iran, or the sands of the Lut, the Kalut were the most impressive sight we had ever seen. These remains of the deposits of the former Lut lake, now sculptured into bizarre shapes by sandstorms, consist of loess which, on account of its iron content, has a yellowish-red colour. The loess

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is stratified, and this fact above everything else distinguishes it from the non-stratified loess of the kind found in China. The material forming the Kalut belongs to the sea-loess type, but, unlike the latter, does not contain any essential percentage of salt. The Kalut stand, corresponding to the direction of the prevailing wind, in long straight lines running exactly N.N.W.–S.S.E. The action of sand and wind has formed "boulevards" which are more than 100 yards wide and which all stretch in this direction. The surface of these boulevards is covered with small corrosion forms, such as rills, furrows, and punctures, formed by the sand and wind.

In some places on the boulevards the deposits of the former lake have not quite disappeared and queer low-lying formations have remained. Groups of regularly formed cupolas are to be seen which look from a distance exactly like a Persian village. In other places flat-topped pillars still stand which have the appearance of tree-stumps remaining after a forest has been felled; while again rows of oval pedestals remind one of a churchyard. The scenery is constantly changing. Newly formed sickle-shaped dunes wander along these boulevards. In places the loamy ground is saturated with salt and has a flaky surface interlaced with streaks and lumps of gypsum. The Kalut hills on either side of these boulevards attain a height of anything up to 200 feet and have the most fantastic forms. They are divided into larger and smaller masses, all having their medial axes running parallel to the boulevards. The Kalut are also cleft by deep ravines. They often tower upwards like bastions, the tops of which are crowned with walls, towers, battlements, and ridges. Round many of the Kalut run ditches, the walls of which show traces of where water once stood, and this makes their similarity to fortified castles the greater. In one row of "desert cities" after another the Kalut stretch, probably in one uninterrupted formation, for about 100 miles in length and 25 miles in breadth along the east of the Namakzar. They are connected with the Shahr Lut, which we had seen in 1928 on our journey from Shahdad to Deh Salm. It is quite clear that there can never have been a route through the desert which can have passed over the Kalut at any point.

On the night of March 24–25 we continued our journey, very depressed, since we saw no prospect of finding a way across the Kalut. At places where the Kalut seemed to be more scattered we approached them closely, but we had no luck. We came across high sand-drifts up which the camels could not climb, and often we had to travel for miles to find a passage through to the next parallel boulevard. As soon as day broke we ascended a high point in order to look round. It was true that in the far distance, to the south, the Kalut came gradually to an end, but to our consternation we discovered in the same direction a row of dunes which were obviously a continuation of the great sand waste. The latter seemed to form an unbroken curve round the Lut. It was as if we were caught in a trap.

The 25 and 26 March 1937 were the hardest days we have ever experienced on our desert journeys in Iran. It was extremely fortunate that no storm arose then. Never have we made such demands on camels and men. We had to make big detours in order to avoid the blocks of loess which barred our path and which looked like gigantic men or animals, or again like church

The Kalut boulevards

domes, minarets, or pyramids. By the afternoon of March 25 the worst of the Kalut was behind us. We halted for a short while but could not really rest, for before us lay the sands, the real extent of which was quite unknown. After a few hours we loaded up the animals once more. At length there appeared in the west the very faint outlines of mountains, which must, we thought, be those lying on the farther side of the Lut. Our spirits were cheered by something else we noticed: the track of a fox. We had observed years ago that these animals penetrate right into the heart of the worst of the desert.

The night of March 25–26 we passed in battling with loose sand-hills which we had to cross. They were in the form of perfectly straight and bare lines of shifting dunes, which stretched from north-west to south-east. Between these lines of dunes the firm subsoil, a flat sandy floor, lay free and open. The sand-hills were no higher than 100 feet, but sometimes had very steep slopes which the camels, now beginning their sixth day without water, could scarcely negotiate. The poor beasts had to be pushed, pulled, and beaten. Their legs trembled; they panted, knelt down, and sometimes crept along on their knees. The men too were exhausted, but riding was quite out of the question. Once more we camped for a short time amid the dunes. Our camp was 1000 feet above sea-level. This was the lowest point we had found when crossing the Lut. Since Gerr-i-safid we had descended 2500 feet.

Our memories of the last stage of 34 miles to Keshit are not very vivid. We were overwhelmed by something worse than hunger, thirst, or fatigue, namely the almost unconquerable urge to sleep. The dunes ended suddenly, as they had begun, and we now came to gently rising stony ground, called *dasht* by the Iranians. The camels must have smelt the mountains and water in the wind that met us, for they struggled on of their own accord. By midday of March 26 we could clearly see the dark strip which was the oasis of Keshit, and soon afterwards we were entering the welcome date groves of the place itself.

Our journey had shown us the general nature of the southern Lut. We still knew nothing about the paths of the rivers which flow towards the desert on the south. Neither had it become clear which was the route mentioned by the Arabian geographers. The only certain thing was that it did not correspond to ours. In order to solve these problems we had to return to the Zangi Ahmad desert. The weeks that followed yielded an answer to these questions. All the streams that in winter flow down towards the desert from the mountains of Jamal Bariz, the highlands of the Sarhad, and the mountains lying between these latter and the heights of Nakhlab are united in one big channel. This channel pierces the sand ring round the Lut at its weakest point, which is not far from a spring in the Zangi Ahmad desert called Baluch Ab, and flows, on the other side of the dunes, into a large hollow basin. This basin is a salty swamp lying about 300 feet higher than the other terminal lake of the southern Lut, the Namakzar. If the old maps did not indicate the position of the salt-swamp with exactitude, they were nevertheless right in showing one.

The route of the Arabian geographers did not start from Naziab, as we had at one time supposed, but from the just-mentioned source of water, Baluch Ab, in the Zangi Ahmad desert. The route, starting from the south, followed

the river bed which pierces the dunes, made a detour round the salt-swamp in the west, then continued across flat *dasht* country along the Kuh-i-Malik Muhammad and joined up with the path we had followed from the north. It was a route which did not cross the Kalut at all and which both in the north and in the south had the advantage of providing camel pastures for quite a distance into the desert. The great antiquity of this track is proved by the presence on it of a *mil*, that is, a round clay tower, which centuries of sand-storms have almost completely destroyed. It is still about 12 feet high, more than 3 feet in diameter, and once stood as a sentinel at the southern entrance into the Lut. That the route is still used to-day, although probably only by bands of robbers, is shown by small cairns and similar signs marking the way both at the southern and the northern ends of the route, and by the traces of camel-dung which we found at the latter end. Istakhri's description of رأس الماء (Ras al Ma: *Iranian*, Sarab), the last source of water to be found when coming from the south beyond Daristan, as "a spring which feeds a pond" agrees completely with the present-day appearance of Baluch Ab.

When Sven Hedin in 1910 treated the question of the laws governing the location of the Iranian sand deserts and discussed the accumulation of dunes in Iran, he hardly knew anything of the presence of sand round the southern Lut, although he knew the country thoroughly both from his own experience and from the writings of others. Subsequent explorers do not mention it either. And yet here lies not only by far the greatest waste of dunes in Iran, the place where all the sand of the whole inner Persian desert belt is collected, but also one of the mightiest accumulations of sand in the world. It is astonishing that the presence of a formation so very characteristic of the geography of Iran has remained practically unrecognized until the present time. It is probable that officers of the British Army came into contact with this sand waste in the course of campaigns in southern Iran during the Great War, but there are no publications to indicate this, and when we depict the sea of sand in the southern Lut we rely entirely on our own observations. The one characteristic that distinguishes the whole sand desert from other sandy districts of Iran is its almost complete impracticability: an uninterrupted sea of sand, with nowhere a well or a base from which to cross it, encircles the Lut.

There are several distinct tracts to be distinguished in the sea of dunes.

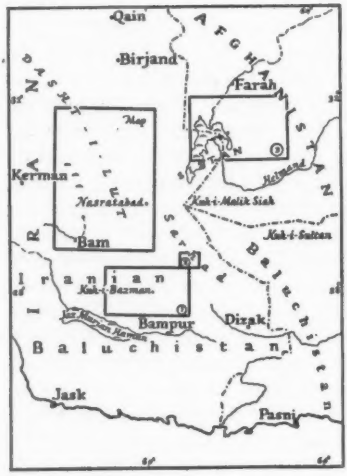
In the narrow belt of sand bordering the Lut in the south-west we have undoubtedly a part of the sand sea which owes its existence solely to the salt-swamp of the Namakzar and was carried by the wind out of this basin. Those masses of sand surrounding in the south and east the Shurgaz Hamun of the old geographers must be distinguished, as regards their origin, from the rest of the sea of sand, although there does not seem to be a physical boundary between the former and the latter. The third and by far the largest division of the sea of dunes is in the south-east and east of the Lut. It consists of the sand masses which, in respect of their origin, belong to the whole inner Persian desert belt.

Characteristics which are common to samples of sand taken from all parts of the sea of dunes are, first, the preponderance of a unified size of sand-grain,

and secondly, the almost perfectly round shape of the grains. Both characteristics show that the sand has travelled long distances. Another interesting fact is the plentiful admixture of volcanic material with the sands.

The sand-hills cover an area of about 5700 square miles. From their northern edge in the south-west of Neh to their south-western spurs east of Keshit they can be traced without interruption for over 180 miles. The boundary line of the sea of dunes is almost everywhere sharp and distinct, except in the south-east, where the waste resolves itself into isolated, sickle-shaped dunes, which disintegrate into low heaps of sand and finally are dispersed by the wind.

The contrast between the bare sands of the south lying in the direct path of the wind and the sands of the east, which are to a certain extent held fast by vegetation, has been mentioned above. The origin of this great sea of dunes is largely to be ascribed to meteorological agencies. We had noticed on our earlier journeys that in this part of Iran it is not by any means the principal winds from the northerly quarters of the compass that prevail, but that for a large part of the year the country is dominated by winds from the south. Under the influence of these contrary winds the sea of sand of the southern Lut was collected together.



There are many more things that could be said about the sand desert, but space is limited. Of our further journeys in Iranian Baluchistan and Afghanistan we can give only a short account, touching on those parts of our wanderings which led through hitherto unexplored country.

With a new caravan, fitted out in Nasratabad, we set forth once more on 22 April 1937 through Nermashir towards the south and reached the boundary of Hudiyan on May 1 (Figure 1). Hudiyan is a mountainous country, very difficult of access, in the west of the Bazman territory, which stretches southwards like a wedge towards the basin of the Jaz Murian. Into this remote district some of the wild southern Iranian tribes have retired. Eruptive rocks of older as well as of more recent formation, such as porphyrite, andesite, and basalt, constitute the countryside. In Bur Kuh, a massive mountain of liparite with deep ravines, Hudiyan reaches its highest point of about 6600 feet. The mountains of Hudiyan are wild and rugged. Deep clefts and cubic blocks of stone combine to form precipitous cliffs which tower up like bastions. Everything is weather-beaten. In all the ravines and on all the flat platforms among the cliffs there lies a covering of coarse debris. Very little fine detritus is to be seen, as the wind has blown it away.

The picturesque valleys of the desolate stony waste of Hudiyan are in-

Southern end of the Kalut

The Kalut resolving into scattered masses

A halt on a boulevard in the Kalut

Baluch Ab

"Mil" at the southern entrance to the Lut

habited by a rough race of people. There are obvious resemblances to Bashagird, a similarly inhospitable land to the south of the Jaz Murian. The population is warlike and suspicious of strangers. Small forts of stone are to be met everywhere. It is the pride of every free man to bear a rifle. Bamari Baluchis predominate; the tribes of Sheikhi, Hashimze'i, Sabeki, and Shuhulibur are also met with. Only the members of the ruling class show the Irano-Arabic characteristics which are peculiar to the Baluchi. The working population has absorbed many elements of a race which was probably closely related to the people who inhabited India before the Aryan invasion. They are betrayed by dark complexions, deep-set eyes, broad faces, and a deep depression at the root of the nose. There are also many people of African negro descent in Hudiyan. With regard to the original peoples of southern

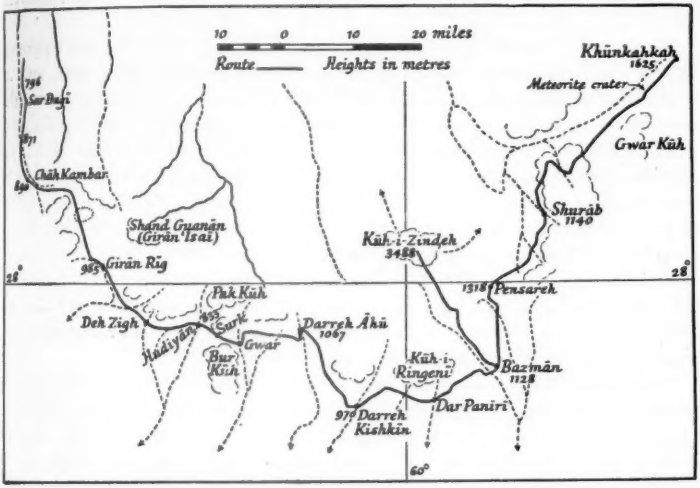


Figure 1

Iran, Hüsing assumes that a dark-skinned race was living along the whole stretch of the Persian Gulf from 'Iraq to India, and that this race was subdued by the waves of Aryan invaders penetrating from the north-west. Sir Aurel Stein also is of the opinion that Aryan peoples migrated from the north-west across southern Iran to India.

Hudiyan is full of the remains of old settlements, the extent of which is surprising. According to oral tradition, these settlements date from the times of Indian peoples with another religion. The houses were erected of unworked stones, a method of building which was still widely spread in Iran in early Islamic times and was only later superseded by building with bricks. Shapeless ramparts and walls of stone, which have been blackened by the sun, indicate the extent of these old settlements. The stone walls were more than 3 feet thick. Broad steps led into square houses. In the bottoms of the valleys one comes across old water-dams which are perhaps of the same type

as the Infidel dams described by Sykes and Skrine. These dams make it easy to understand how meagre sources of water, which nowadays can supply the needs of only a few people, could in former times support settlements consisting of at least several hundred. The present-day population lives, like that of Bashagird, in huts of matting which look like bee-hives. In both places the huts are called *hasiri*. As in Bashagird, these shelters stand in scattered groups on old terraces above the bottoms of the valleys and are generally invisible from the beds of the rivers.

The wealth of the region consists of its date plantations. The chief settlement is Hudiyan, with about a hundred huts, lying in the centre of the country and in the valley of the same name. There are many other settlements like Deh Zigh, Surk, Gwar, and so on. The country's means of communication consist only of primitive mountain tracks, which converge on the Hudiyan valley.

We stayed in Hudiyan only from May 1 till May 9. We were not welcome among the inhabitants, who often refused to let us enter their huts, and it was advisable not to linger too long. From Hudiyan we travelled eastwards into the Bazman district, which was visited by Sir Percy Sykes forty years ago.

The country is dominated by the 11,500-foot high Bazman Kuh. It consists of dazite and, like its sister volcano, the Kuh-i-Taftan, it towers high over the surrounding country. Its summit is a climatic island and seemed to us to merit a closer examination of its flora and fauna. Our collections have been handed over to specialists, whose results have not yet been worked out. We climbed to the top of the mountain on May 19. The ascent is not difficult but nevertheless wearisome, since the sides of the mountain are almost everywhere steep and covered with a loose, deep layer of fine detritus. No water is to be found for the last 5000 feet.

The Kuh-i-Bazman is called by the natives Kuh-i-Zindeh, the Mountain of the Living One, after footprints of Khizr-as-Sallam, the saint who has never died and tarries always among the living. In contrast with the Kuh-i-Taftan, the Kuh-i-Zindeh is dry and uninhabited. Only one single small valley on the southern side, the Ziyarat valley, shows a little more vegetation and is sparsely settled by Bazmani Baluchis. Without having any of the usual alpine charms, the mountain landscape of the Kuh-i-Zindeh yet possesses a fascination of its own.

On May 25 we left the Bazman district and, setting out northwards past the Gauhar Kuh, the Jewel Mountain, eventually reached the massif of the Taftan (Figure 2). During this journey we looked for and found the crater formed by a meteorite which has been described by Dyer and Skrine. When we saw the crater it was quite dry. The hollow is being filled up again, as the land slopes from the east. The levelling out is proceeding rapidly. The hole is now 22 feet deep, 10 feet less than in 1921 when Skrine saw it. We are not able to give a better explanation of the origin of the crater than that it was caused by a meteorite.

At the beginning of June we began the ascent into the highlands of Iranian Baluchistan, as Skrine has called this part of the country. Skrine discovered here in remote valleys traces of an old civilization which was destroyed by the invasion of wild hordes of Baluchis, Afghans, and Kurds. The north and

north-west of the mountain massif was not visited by Skrine, and in order to complete his investigations we wished to explore these high-lying valleys.

Certain valleys like the Nārūn valley (not to be confused with the Narūn valley, which Skrine travelled through) we found to be inhabited exclusively by more or less pure-blooded descendants of the Persians who were once the rulers of the land. They are called Tamindani after the likewise Persian inhabitants of the Tamindan valley to the west of the Kuh-i-Taftan. The Baluchis often call them simply *kuhi*, "mountain folk." In some valleys the Tamindanis live side by side with Baluchis, as in the Senib valley. Many other valleys are inhabited solely by Baluchis. In the Garok valley live Meskanze'i,

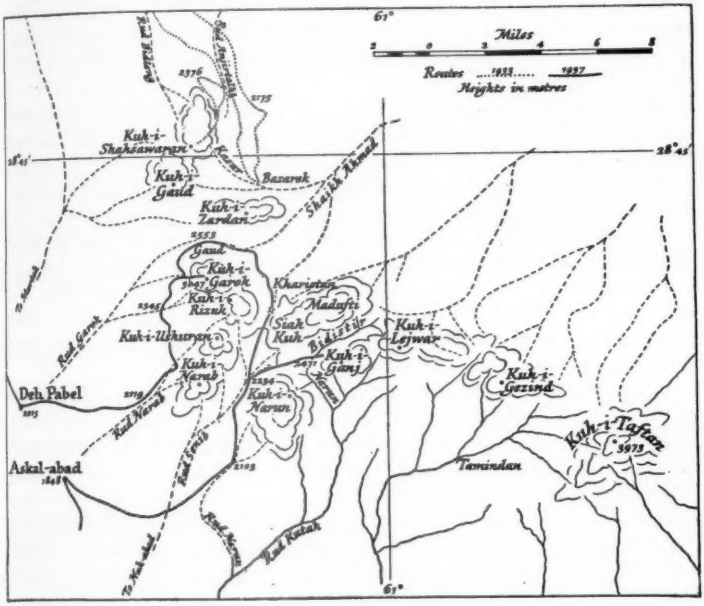


Figure 2

a people descended from Tamindani and Rikki Baluchis. The Mir Baloze'i in the Narāb valley are of Kurdish descent.

In almost every valley there are remains of the old stone buildings of the *Kafar*, the Infidels. One can distinguish houses, forts, cemeteries, irrigation dams and aqueducts. As in Hudiyan, these were all built with rough, unworked stones. Some of the old houses have been repaired and provided with some sort of roof by the present population, and are used as stores for corn or as stables for cattle. Nowadays the people live all the year round in goat-hair tents which are shifted from place to place according to the season of the year.

In the very remote valley of Bidistir in the west and the north of the Kuh-i-Ganj, the Treasure Mountain, we also found traces of stone-smelting from

a former age. On both slopes of the valley lie piles of slag. It is not known what metal was obtained here. One of the samples of slag was a piece of silicate slag which contained principally iron and manganese; perhaps the iron was extracted in a primitive manner. The stone of the living rock in the valley is dacite.

Most of the valleys, regarded as landscapes, are very beautiful, particularly the Shaikh Ahmad valley. Wild rose bushes are in bloom everywhere. Light dacite rocks form a labyrinth of stone needles and towers on either side of the slopes. Bedded deep in this stony splendour lie tiny cornfields. In the Garok valley there stand six ancient cypresses. The circumference of the trunk of one of them is 39 feet, and it is therefore even larger than the famous tree of Sangan which has several times been described by explorers.

On June 14 we reached Zahedan, the terminus of the great trade route *via* Nushki to India. We were very weak from attacks of fever, but thanks to the kindness and care we met with in the house of the British Vice-Consul Major Campbell and his wife we were able to recover and to continue our journey on July 7 *via* Zabulistan to Afghanistan.

A considerable amount of literature has been written about Sistan, the present Zabulistan, and to this we could add very little that was new. The journey along the Khash Rud, which lasted from July 17 to 26, was extremely exhausting at that hot season. We recorded midday temperatures of the air as high as 110° F., together with a relative humidity of 4·2 per cent. The region of the "Wind of 120 Days" extends eastwards along the Khash Rud only as far as Lukhi, the present-day capital of the district, and from Lutak onwards its strength begins to wane.

We crossed the Afghan frontier at Qal'eh Kang (Figure 3). This place, which G. P. Tate described in 1903, lies in ruins. Present-day Kang is situated just to the north of the former settlement. In recent times a road has been built northwards from Qal'eh Kang to Farah and southwards to Chahar Burjak, running more or less parallel to the border, and therefore a road which may some day be of strategic importance. We found that Chakansur, the former capital of the Afghanistan part of Sistan, to the east of Qal'eh Kang, was a deserted village. The settlement here was given up twenty years ago on account of lack of water.

The Khash river was for the most part dry. It is only above Gawmishi that its water does not dry up even in the hot season. The middle of March is the period when the water is at its highest. The fall of the Khash Rud from its mouth in the Hamun basin to Lendi is not more than 1 foot in 1000. From Lendi onwards, where the Khash river takes on a more northerly course, the fall is greater. It is a grand sight to see the Khash Rud flowing down from unknown mountains in central Afghanistan into the plain, then winding into the distance through burning deserts, and mingling its waters, when in good years they have been fed by the melting snows, with those of the Helmand river. The bed of the Khash Rud is thickly covered with vegetation and extends through the desert like a narrow, never-ending oasis. Cultivated land and desert here impinge sharply on each other. All living things cling to the thin moist line of the river bed.

The Khash Rud territory is inhabited by a very mixed population. On the

Deh Hur, with Bur Kuh in the background

Remnants of old settlements at Surk

Girr, with Kuh-i-Ringeni in the background

Fortress of Hajji Agha Khan at Khash

lower course of the river one finds settlements of Baluchis as far as Shishaweh. An island of Iranians is formed by the places Khash, Qal'eh nau, and Lukhi. From there onwards the Khash Rud valley is inhabited solely by Pashtu-speaking Afghans of the Nurze'i family of the tribe of Durrani. The edge of the desert is full of ruins with such names as Gul-i-safid, the White Flower, Qal'eh surkh, the Red Fortress, and so on. In former times the country was thickly populated, and the waters of the Khash river once flowed through canals far into the desert.

The former capital of the Khash Rud district is Khash, on the left bank of the river. It is quite hidden, like a medieval town, by stout walls. To the west a fortress has been built into the wall where the feudal lord of this district,

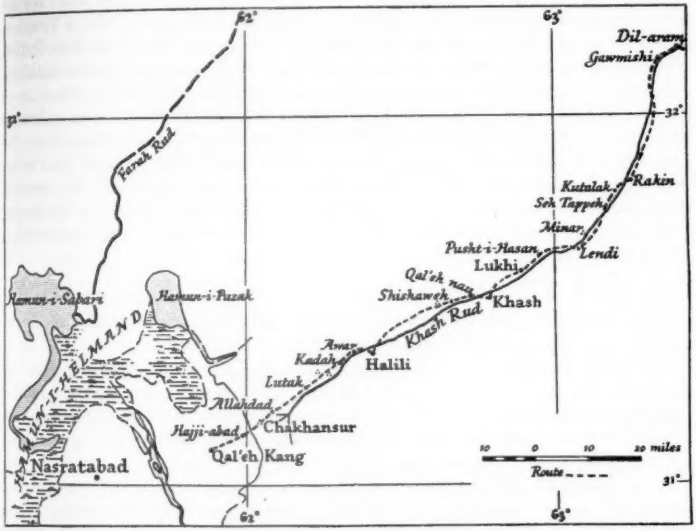


Figure 3

Hajji Agha Khan, used to live. The three hundred inhabitants of Khash are all his serfs. When we arrived at Khash, Hajji Agha Khan had been in custody at Qandahar for several months, but he had left behind him a fierce dog that barred the way to every one who wanted to enter the castle.

The surface of the Khash desert has been formed chiefly by wind erosion. Its deeper-lying western area is a clay desert covered with low *yardangs*, whose edges have been undercut by the wind. Towards the east gravel begins to cover the level ground. There is very little sand. We should expect to find deserts formed by wind deposits in Afghanistan only in those places where the country has more than one prevailing wind. Just as the great sea of dunes round the southern Lut is the place where sand from the whole inner Persian desert belt is collected, similarly the sand masses of the Rigistan have probably been accumulated from the whole Afghan desert belt by the "Wind of 120

Days," which has been diverted to the east. Here a wide field of investigation lies open to future explorers.

At Dilaram we reached the main road to Qandahar. As a result of unrest among several tribes on the road to Kabul we had to leave Afghanistan *via* Chaman on August 1.

I would like in conclusion to thank the Imperial Government of Iran and the Royal Government of Afghanistan for the hospitality and help which our expedition received from them.

DISCUSSION

Before the paper the CHAIRMAN (Colonel Sir CHARLES CLOSE) said: We are privileged to be about to listen to a lecture by Dr. Alfons Gabriel, a Viennese doctor of medicine who has spent a great deal of time in the Dutch East Indies. Not content with travelling in the Dutch East Indies, he spent three holidays, altogether amounting to about three years, in the deserts of Iran. Dr. Gabriel has also travelled in Arabia and he has therefore a fairly wide acquaintance with this world's surface. To-night he is going to tell us something about the Lut, the great desert of Iran and Iranian Baluchistan. Though I am glad to say that there are a few in this audience who know something about the country, there are not very many, and we shall be able thoroughly to enjoy the lecture and to appreciate it from the point of view of the newness of the information which I now ask Dr. Gabriel kindly to impart to us.

Dr. Gabriel then delivered the lecture printed above, and a discussion followed.

The CHAIRMAN: Sir Percy Sykes is here, and as he knows more about the country than most people I will ask him to say a few words.

Sir PERCY SYKES: I should, first, like to say as to the word "Lut" that it is identical with that of the patriarch Lot, and you can understand why. I understand that the Dead Sea is known in Palestine among the Arabs as the Bahr-i-Lut, or the Sea of Lot, and the connection between the salt country and the patriarch and the pillar of salt is quite intelligible.

I can assure Dr. Gabriel that my officers during the war never went hunting up and down the sand-dunes; we always avoided them as far as possible. I have crossed the Lut in about five different directions, but I do not now wish to dilate upon its beauties. I must say that I did enjoy enormously with Major Brazier Creagh—and we were the first Europeans to do it—climbing both those mountains, the Kuh-i-Taftan and the Kuh-i-Bazman. The Kuh-i-Taftan is particularly interesting because it is a volcano in the solfatara stage of existence. It is situated about 200 miles from the sea, and in the distant days when I climbed the mountain the geologists had laid down that there were no active volcanoes more than 100 miles from the sea. When I came home and said I had discovered one, I was told that it was impossible. However, I produced specimens of sal-ammoniac and sulphur which I had brought back, and so the geologists kindly changed their theory.

In conclusion, I should like to say I am most grateful to the lecturer. I was in the country as a cavalry subaltern to look around and survey; I had no scientific training. I have been able to learn a great deal from our lecturer this evening, and I thank him.

The CHAIRMAN: Major Campbell was Vice-Consul at Zahedan when Dr. Gabriel called there after his journey. Perhaps he will add a word or two.

Major J. CAMPBELL: In February last year I heard that Dr. and Mrs. Gabriel

were shortly to visit Zahedan. I heard no more about them except that they had entered the desert somewhere north of Bam. Months passed, and I did not expect to hear of them again. In June however my Berbery servant came to me and reported with some excitement that a strange black man with a beard and a strange lady waited without. As beards are not worn in Iran nowadays they must, of course, be foreigners, and the servant added, confidentially, that they looked hungry and rather like beggars. They were the long-awaited Dr. and Mrs. Gabriel. The desert had not been kind to them, for they were very lean and incredibly blackened, not just tanned, by the sun. Suffice it to say that they left us later each weighing 12 lb. more than when they arrived.

During their stay in our house we heard from them of the many interesting and exciting things which befell them; and as I had had some little experience of the desert, I realized the great risks they had taken in the cause of science.

About that time the local Governor-General, a man who knew his country very well indeed, was riding along a few miles outside Zahedan. He was not quite sure about the ground, but on seeing that there was vegetation, *i.e.* reeds, he thought he could ride across it; but within a few feet from the reeds his horse went down underneath him into what seemed to be a pit of whitish dust, largely saltpetre and salt. He managed to throw himself clear, but could not get his horse out. That, for a man who knew his country well, was a somewhat alarming experience. You can therefore imagine the risks that Dr. and Mrs. Gabriel ran when traversing these unknown deserts.

The CHAIRMAN: I will ask Mr. Harrison, who knows something of the geology of the region, to say a few words.

Mr. J. V. HARRISON: It has been a great privilege to listen to the lecture by Dr. Gabriel. He has made light of the great risks he ran during his journey in that difficult country. The camels with which he performed his journey are not of the same calibre as the animals with which Philby, for instance, penetrated the deserts of Arabia. By undertaking a journey of such length and difficulty Dr. Gabriel showed himself to be a most fearless traveller. Indeed only those who have been in such parts can really appreciate the sterling qualities and intrepidness of Dr. Gabriel as shown by this exploration.

Dr. Gabriel mentioned that the feet of his camels were scorched by the sun-heated sand. In Moscow last year I happened to meet the manager of a company which is exploring the Dasht-i-Kavir region, and he said he had just received a letter from some of his colleagues stating that tent temperatures were of the order of 136° F., some 20° more than Dr. Gabriel mentioned having experienced. The Anglo-Iranian Oil Company has long kept a record of sun temperatures that obtain somewhat farther south in Persia. It is normal for sun temperatures in the summer to register approximately 170° daily.

The country of which Dr. Gabriel has been speaking to-night I have only viewed from a mountain some couple of days' journey north of Bam, but I have crossed his tracks and heard accounts of his journeys in country somewhat to the south, in Bashagird. In Bashagird the people are very similar to those Dr. Gabriel has been moving among. Their habits also are similar. It is some four months since I visited the capital of Bashagird, Anguran, in which Dr. Gabriel camped in 1928. It is still a village consisting of a few huts overlooked by a mosque and the ruins of an old fort, and depending on the cultivation of a few date palms. The chieftain of the place who received Dr. Gabriel was visiting the new governor of Bashagird on the edge of the Jaz Murian on the occasion of my arrival. The Jaz Murian is one of those big sinks or sumps of which there are many in Iran. At the centre it is approximately 1000 feet above sea-level. Along the south side and at its eastern end the country rises to 4500

feet, while to the north the Jamal Bariz range attains an altitude of 11,000 feet. Two rivers drain into the Jaz Murian, the Halil Rud from the north-west and the Bampur from the east and north-east. These rivers lose themselves in the big depression, but there is no salt in it. The water is surprisingly potable all around the edge of the sand and silt that forms the central part. The origin of this inland basin is a subject of geographical interest, and the answer is to be sought in the west, where the watershed is only of the order of 1400 or 1500 feet above sea-level. Can it be therefore that the Jaz Murian represents merely a part of the wide valley of these two rivers that once debouched to the west into the Shamil-Bandar 'Abbas region? I think it is possible because there has been very recent faulting, which may account for the uprise of a block to the west, thereby cutting off the outlet to the sea. But as geologists as a class have been so thoroughly ticked-off by Sir Percy Sykes I had better not say anything more about geology.

The CHAIRMAN: Major Bagnold knows a great deal about sand-dunes, and I will ask him to tell us something about them.

Major R. A. BAGNOLD: Dr. Gabriel described in the early part of his lecture, very vividly indeed, the several sandstorms which he encountered. I felt, before he went on to describe the other unpleasant parts of his journey, that I should have liked during that period to have changed places with him. I have returned from Egypt, where I spent two months waiting for sandstorms—and only two feeble ones came along.

I was much interested in Dr. Gabriel's pictures of the Kalut, with its parallel lanes separating the straight ridges which are all that remain of the old lake. The same extraordinary straight lanes occur in the western Egyptian desert between the parallel lines of sand-dunes. The scale appears to be about the same in both cases, and both are the result of wind action. I was also most interested to hear something in confirmation of what I had found in Egypt: that vegetation in a very dry country grows more easily on sand-dunes than elsewhere.

The CHAIRMAN: We have listened to a singularly interesting lecture about a country of which most of us have previously known very little. I should like to point out in connection with the temperatures mentioned by the lecturer that there are places in this world where one experiences higher temperatures even than those mentioned by Mr. Harrison. There is a place in Libya where a screen temperature was reported of 135° F.

The character of the country, a description of which we have been listening to, clearly explains why Iran has such a small population. There is an area, some 800 miles long, of desert or half-desert country which maintains no population whatever, and Iran itself has only about twenty people to the square mile.

In your name, and in the name of the Society, I offer our hearty thanks to Dr. Gabriel, not only for the excellent lecture he has given us, but also for the fact that he and his wife have travelled specially across Europe in order that the lecture might be given.

THE PHYSICS OF AN ICE-CAP

R. MOSS

Afternoon Meeting of the Society, 11 April 1938

IN this paper I intend to discuss more fully the detailed structure and history of the North East Land ice-cap in the light of observations made by the Oxford University Arctic Expedition 1935–36 at the central station on the west ice, which was manned from 9 September 1935 to 11 June 1936. These observations fall naturally into two categories: those dealing with present-day surface conditions, and those taken below the surface of the ice-cap which are informative of its past history. From these it should be possible to make some inference about the probable future tendencies of the ice-cap as a whole.

Accumulation

The surface is nourished by three agencies: rain, frost, and snow; in addition there is of course localized accumulation by drifting of snow which originally had been precipitated on other parts of the ice-cap. Rain only occurred once during the period of observation and it is improbable that it plays any significant part in the supply, although super-cooled water droplets in condensing on the surface in the form of glazed frost (*Glatteis*) must account for a good deal of it, and are also of great importance in the formation of "crusts" as discussed below. Hoar and rime are more prevalent and cause some growth of the surface, but as far as our observations go this effect is not perhaps as great as might have been expected. Nearer the coast however they are of much greater importance, frost accumulation at the northern station which was only 5 miles from the sea being more than three times that at the central station during the four months, November to February, when simultaneous observations were taken. It was very seldom that frost crystals actually formed on the surface (they were observed on thirteen occasions), and when they did they were of very low density and formed a loose soft layer never more than 1 cm. deep and more often only 2 mm. (Plate 1). They were much more often deposited on solid obstacles, but when this occurred there was usually little or no change in the snow surface either in appearance or density: for instance, when the photograph facing p. 214 in the *Journal* for September 1937 was taken cones 8 cm. long were formed on the wind vane, but there was no appreciable change in the density of a small sample of the snow surface as compared with its value the previous day.

The rate of accumulation owing to precipitation in the form of snow was ascertained by the use of a Mougin snow gauge (Fig. 1) acquired from the Norwegian meteorological service. It was emptied daily at noon, the snow which it contained being melted and weighed. It consists of a long narrow collecting vessel 15 cm. square surrounded by a large guard ring to avoid the collection of drifting, as opposed to falling, snow. There seems to be no reason why this should not collect all the falling snow, but it does not by any means eliminate all the drift which is so prevalent on the ice-cap (119 days

in 255), and thus its record gives an upper limit to the value of the precipitation. This, over the whole period of observation, amounted to 158·6 mm. of water. There were fifty-eight occasions on which a "trace" is recorded. At the most each of these can be equivalent to 0·1 mm., thus totalling 5·8 mm. as a maximum. Allowing the very generous estimate of one hour per diem for the period when the collector was in the tent (it would be better to use two collectors in relays so that one would always be in action), the maximum total snowfall would thus be equivalent to 24/23 (158·6+5·8) mm., or, in round numbers, 170 mm. of water. This compares with 113 mm. (uncorrected) in the base camp records over the same period. During the time that the northern station was occupied the respective precipitations were: northern station 98, central station 84, base camp 60 mm. Cumulative daily values for the central station are plotted in Fig. 2, curve (iii).

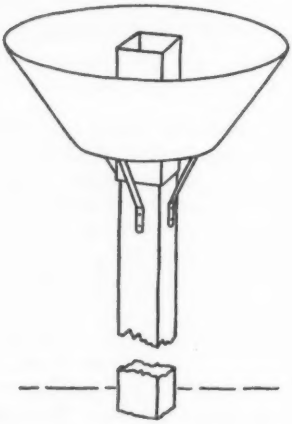


Figure 1. Mougin snow gauge; average height of collecting surface 2 metres above snow level

To measure the actual rate of rise of the snow surface six vertical wooden stakes 4 cm.×2 cm. and 3 metres high, clearly marked with bands of paint, were used. In order to prevent their sinking into the snow each was fitted at its lower end with two wide horizontal cross bars about 50 cm. long. Holes were excavated as far as the first thick blue band in the firn, and the cross bars were placed upon it as providing a reasonably constant fiduciary level. The holes were then filled and the surface relevelled, but they were left to settle down for a few days before any readings were taken. In order that they might be safely visited during the dark time the stakes were all placed not more than 150 metres from the tent. Even so it was none too easy to make one's way out to them during a blizzard, and owing to the presence of tents, packing-cases, and a snow hut during the establishment of the station they were not entirely outside the region in which it caused drift to accumulate (Plate 2). Small-scale experiments showed that an obstacle will produce a drift at least 15 times as long as its own height, and every drift will act as a source of others on a change of wind direction. The effect of an obstacle however is very considerably less on the windward side, and therefore in Fig. 2, curve (i), the values of surface height are plotted from the average increase as recorded on those stakes which were known not to have been in the lee of the station since the previous noon, at which time observations were taken every day. Curve (ii) shows the daily average rise for all the sticks. The similarity between the general shape of these curves is striking. From measurements taken on the

bamboo staves of the flags, which were placed every quarter of a mile across the ice-cap to mark the route to the station, it would appear however that curve (i) is rather overcorrected and that the true values should lie between (i) and (ii). Thus it may safely be concluded that this method gives the total and the detailed rate of rise to within about 15 per cent.

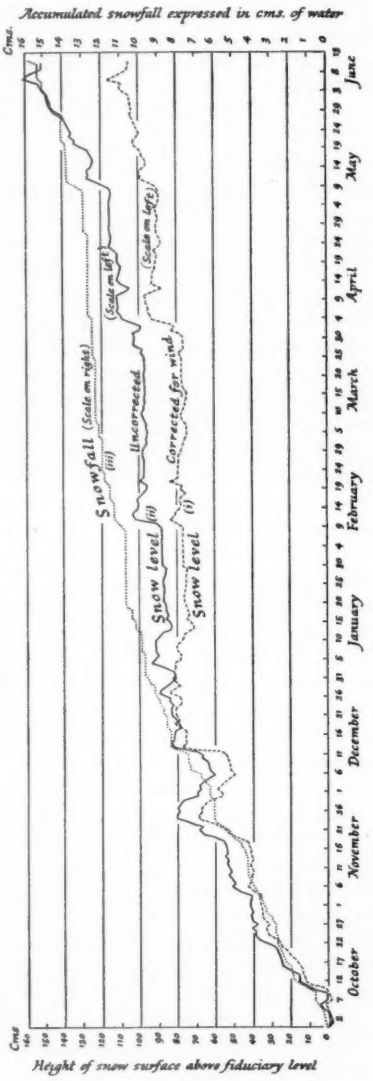


Figure 2

The density of the consolidated snow and upper layers of the firn was determined from time to time by digging pits and extracting 500 c.c. samples in an aluminium cylinder which was used with a small portable steelyard as described by Seligman. An average value of 0·34 gm./c.c. over the whole period of observation was thus obtained, which would give the total observed snow increment of 110 cm. a water equivalent of 374 mm., which may be compared with the total precipitation of 170 mm. Or perhaps a more striking way of expressing this comparison is to compare observed and calculated increases in the height of surface: 110 cm. and 17·0/0·34 or 50 cm. To account for this discrepancy of 60 cm. we have two alternatives: it might be due to frost or to drifting. If it were due to frost it would be greater near the coast than at the centre of the ice-cap, since the observed depositions of frost are as 3 : 1 at these places, while the increase in height of the snow surface as recorded on the flag poles varies but slightly at different parts of the ice-cap, being only a few inches higher near the coast. If it were entirely due to frost the discrepancy would be of the order of $3 \times 60 = 180$ cm., which is certainly not found to be the case. It may be contended that the observations at the northern station only extended over

four months while the above refers to a period of nine; but by taking values from Fig. 2 for the period of the northern observations, viz. 1 November–21 February, we find the observed and calculated heights are 45 cm. and 26 cm., which are in roughly the same proportion as before.

We are therefore driven to conclude that the excess of accumulation over precipitation is due to drifting snow.

Ablation

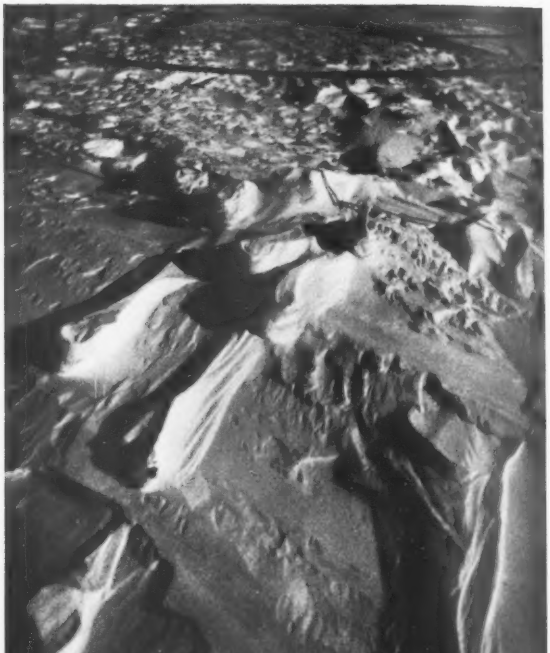
Some of the individual trends of the curves are of interest. All the sharp falls of level are accompanied by winds of force 7 Beaufort (35 m.p.h.) or higher, and most of them occur almost immediately after the recording of a sudden rise. In the cases where there is a few days' lag—*e.g.* 24–27 November—the daily record of the surface conditions shows that during this intervening period the surface remained soft and unconsolidated, and that after the gale it had become quite hard. The question now arises whether this fall in level is an apparent one due to "wind packing" (Seligman) or whether it is a real effect of the material actually being carried away. The examination of individual features such as sastrugi shows clearly that it is to be ascribed almost entirely to the latter action. For instance where the old surface had been artificially compressed, the snow underneath it was too hard to be abraded by the drift which carried away its surroundings during gales and thus left "raised footsteps" (Plate 3). The tallest footstep in Plate 3, which was taken on April 14 after the sudden fall of April 11–12, was 21 cm. high. Some of these "raised footsteps" were remarkably durable and preserved their detailed structure for a surprisingly long time. Plate 4 was taken more than three weeks after the sledge and dog-team which made it had left the station, and although the surface had been covered and re-exposed several times during the interval it still showed individual paw marks. It seems then that wind action, at least in gales, wears the surface down as far as a hard layer which is more or less able to withstand the abrasion, and which, owing to its permanent nature, probably exerts a profound effect on the firn subsequently to be formed from it.

It is doubtless significant that the large increases of the accumulation curve in excess of direct precipitation occurred with strong westerly winds, indicating an abnormally large supply of suspended drift material from that direction. It seems a little rash to suggest that this might have been carried across Hinlopen Strait from the New Friesland ice-cap, and yet we have direct evidence that drift from the North East Land ice-cap is carried some miles out to sea, for after southerly gales the black rocky cliffs of the Seven Islands which stood some miles out from the north coast were often found to be crossed by a white band of driven snow about 300 feet above sea-level.

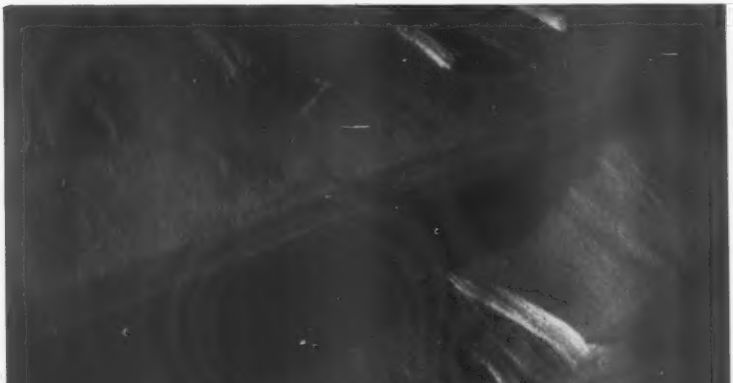
The drops in the curve for May 14 and June 8 and 9 are due to true evaporative ablation occurring under clear sky with high temperatures. The rate at which this process occurs under favourable conditions is truly remarkable: a drop of 10 cm. was recorded in three hours on May 14 when the air temperature reached its maximum value of 36° F. and the relative humidity fell to its minimum of less than 80 per cent., under an almost cloudless sky with a moderate south-south-west breeze (the amount shown in the record is much

1. Deposit of frost crystals on snow surface and guy-ropes during the establishment of the central ice-cap station

2. Growth of long drifts behind obstacles



3. Raised footsteps



4. Raised footsteps of dogs and sledge tracks

less than this owing to the fact that more accumulation occurred before the next noon-day reading of the stakes). Thus in some seasons the total ablation during the short summer period may be very large. However the necessary coincidence of favourable circumstances did not occur very often. It happened only once during May, and since the observed days of cloud as recorded at the base station are much the same during May, June, and July, it is probable that there were only a few short periods of this direct ablation during the whole of the summer.

Sastrugi and barchans

Of the many different natural surface markings and sastrugi the barchan type was by far the most striking; and although the apparently rather critical conditions necessary for its complete development were seldom attained, it seems that an allied mechanism is responsible for the growth of other commoner forms. Barchans were particularly well formed on November 25. They take the form of large arrow heads pointing up-wind (Fig. 3) and are regularly spaced in relationship to one another. Their dimensions may vary a good deal on different occasions, *e.g.* November 25, 3 m. long and 5 m. wide; March 3, 10 m. long and 12 m. wide; but at any given moment they are almost identical in size and shape. They are not a static phenomenon: each drift moves bodily in the direction of the wind with a velocity of the order of 1 cm./min., at the same time changing its shape. The mechanism of this change is fascinating to watch. In the early stages when the simple arrow head is formed snow crystals at rest near the apex are carried over the drift and redeposited at the other side, rolling and sliding over one another rather than being carried bodily through the air (Fig. 4a). To begin with, the drift consists of hexagonal snow crystals of a fairly uniform size between 1 and 3 mm. in diameter, the great majority of them being 2 mm. across. As they roll over and over one another they become broken up into individual spicules of ice about 1 mm. long, and the relative density of the whole mass increases from about 0·15 to 0·25 as it becomes more closely packed.

When this consolidation has advanced about half its course a new process begins. The wind passing the horns or barbs of the bow develops into a pair of vortices, the right-hand one looking up-wind being clockwise and the left anti-clockwise, as in Fig. 4b. At the same time quite strong winds blow laterally very close to the leeward face of the bow, meeting in the middle where they form a small low point of drift which tails off down-wind. The first result of this is that more snow is deposited at the tips of the barbs and they thus extend to leeward more rapidly than the rest of the drift, which accordingly becomes progressively elongated (Fig. 4c). At the same time the middle part of the drift, instead of flattening out gradually, begins to rise higher and where the longitudinal air stream over the top crosses the lateral wind a small cornice is built out as in the cross section. This is certainly due to some kind of wind packing of the crystals which have now been reduced to the requisite size and shape for this process to occur, but their cohesion is still small and every two or three seconds the cornice breaks off and falls to the bottom of the escarpment where it remains. The average rate of growth of this cornice over a few minutes is remarkably regular under given circum-

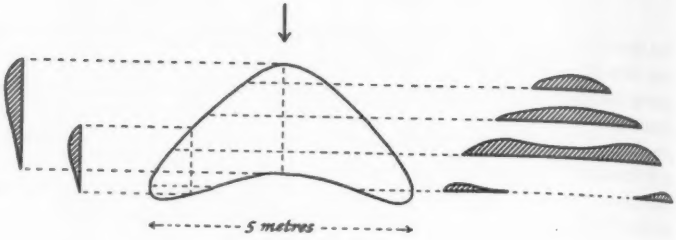


Fig. 3

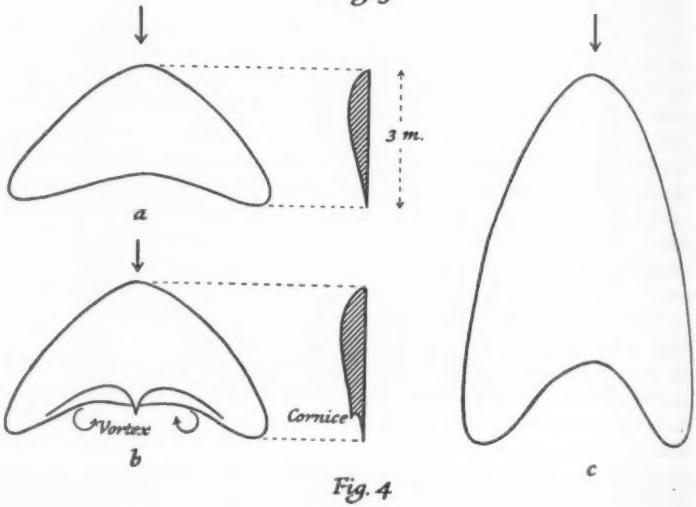


Fig. 4

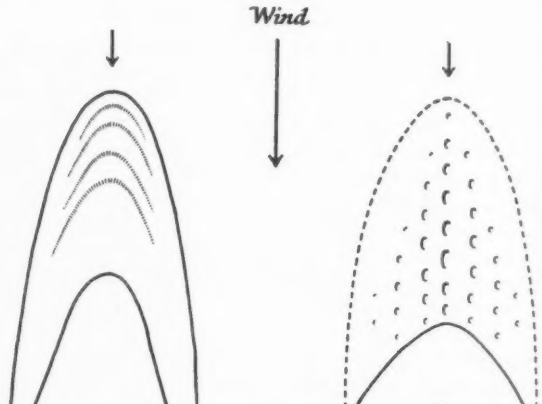


Fig. 5

stances: for instance on March 3 a series of measurements was taken by pushing stiff vertical wires through various salient features of the barchan into the hard snow below at intervals of ten minutes, thus determining the progress of these points in the direction of the wind. For the middle of the cornice the velocity ranged between 1·00 and 1·12 cm./sec., while that of the horns was between 0·22 and 2·23 cm./sec. Always when barchans were formed the wind was variable in strength but absolutely constant in direction. It was not gusty but varied gradually and fairly regularly between force 2 and force 5 with a period of 5 to 10 minutes: its value when averaged over a period of an hour was always between 15 and 16 m.p.h. Owing to the fact that these observations had to be made without assistance it was not possible to attempt to correlate the variation in growth of the horns of the barchan with the wind velocity. As the horns grow longer they do not continue to diverge but tend to become parallel to one another, and after a time the growth of the cornice outstrips theirs so that it fills the gap between them, thus forming a long cigar-shaped drift, a type which was seen fairly frequently without any immediately preceding observation of barchans.

Sometimes the barchans would be destroyed without passing through the cigar-shaped stage. Quite often they had grooves near the apex reproducing the outline of the arrow head in a series of ripples (Fig. 5a). These then gave rise to what looked exactly like an interference pattern producing a perfectly regular system of little pits (Fig. 5b). There must have been very strong eddies inside these because they became so firmly wind-packed that they were able to remain long after the barchan proper had moved away downwind, and often endured for many days after they had been formed. Plate 5 is a photograph of part of one of these systems taken during the dark time, and clearly shows the regular arrangement of the "ripples" which in this case have a "wavelength" of about 30 cm. Sometimes the ripples were only half this size and sometimes very much bigger. Their upper layers were much harder than the lower, so that often they would become undercut if the wind strength increased, giving rise to "undercut sastrugi," which thus often developed projections on the windward side that attained the remarkable length of 50 cm. before they broke away (Plate 6).

Whenever barchans were found there was a hard smooth layer beneath them and their temperature was less than that of the atmosphere, *e.g.* on March 1 values were −32°·0 C. and −30°·6 C. respectively. The conditions for their development would therefore seem to include the presence of snow crystals of suitable density, structure, and probably temperature, moving over a smooth foundation layer under the action of a fluctuating but not gusty wind of an average force of about 15 m.p.h.

Other surface markings were more haphazard and did not appear to have any systematic structure when formed by winds of varying directions.

Wind crusts

As has already been said, the hard layers which are essential to the production both of barchans and of raised footsteps are able to withstand the abrasion of winds up to at least force 8. They are so hard that one can produce no impression upon them, when clad in finnesko, by jumping on to them with

all one's might. They are very thin, not more than 2 mm. thick, and yet so strong that when prized up with a spade they produce slabs a metre or more square which carry with them 5 or 6 cm. of the somewhat softer subjacent layers. In appearance they are not markedly different from the more usual and somewhat softer layers, but when examined on a clear day give an almost specular reflection of the sun, indicating that in detailed structure they must be very uniform.

At intervals of about a month pits, 2 metres deep, were dug in order that the layers near the surface might be investigated and their density and temperature determined. In their walls the layers were quite clearly differentiated and the extremely thin wind crusts were quite obvious. The photograph in the *Journal* (90 (1937) facing p. 219) was taken in the dark time; a lantern was placed in one of two pits separated by a thin vertical wall of firn, the camera being placed in the other.

In the pits dug in March, April, and May a 10-cm. layer of uncompacted angular crystals was found at a depth of about 90 cm. Below it was a hard blue band of the old firn. These crystals were so loosely packed that when the pit was dug they would pour out in a stream like corn from a hole in a sack, and later when a new attempt was made to work the ice drills they so effectively wedged the drilling rods in the bore hole that progress was practically impossible. This layer preserved its relative density almost unchanged at 0·294, 0·292, 0·284 respectively for the three months,[1] values much less than those of the adjacent consolidated layers which would not be rigidly supported by it. A sudden adjustment of this layer to a greater density might easily account for the "firn stoss" which was observed on three occasions. Surface settlements like the "Barrier hush" described by antarctic expeditions were only observed on one day, 31 October 1935, when a faint rushing sound was heard receding as one walked over the very thin crust recently formed over a 2 mm. layer of soft light snow, which had been deposited the previous day over an older wind crust.

Observations below the surface

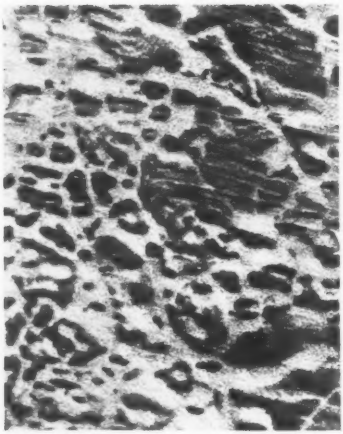
The layers under the surface were investigated in the actual construction of the station, which involved the excavation of about 40 tons of firn, and in a shaft which was driven to a depth of 10 metres below it. Layers of white semi-crystalline firn alternated with bands of hard bubbly ice which appeared blue-green by comparison. As the depth increased the firn became less and less, while the blue bands increased. Although the blue bands reduced the rate of digging, they were useful in that they provided solid roofs and floors to all the tunnels. Contrary to expectation they were not always level or continuous, at all events in the upper strata. Fig. 6 for instance is a drawing of the blue bands in the wall of the main tunnel with an exaggerated vertical scale. Clearly pits dug a few feet apart may lead to quite erroneous conclusions. In the metre of snow and firn just below the surface this effect is very much less and also seems to be growing smaller at a depth of 10 metres, but at 2 or 3 metres the bands do not seem to be arranged on any definite

[1] On the plate in the *Journal* (90 (1937) facing p. 219) the figure is wrongly given as 0·4.

5. Interference pattern remaining after the passage of a barchan

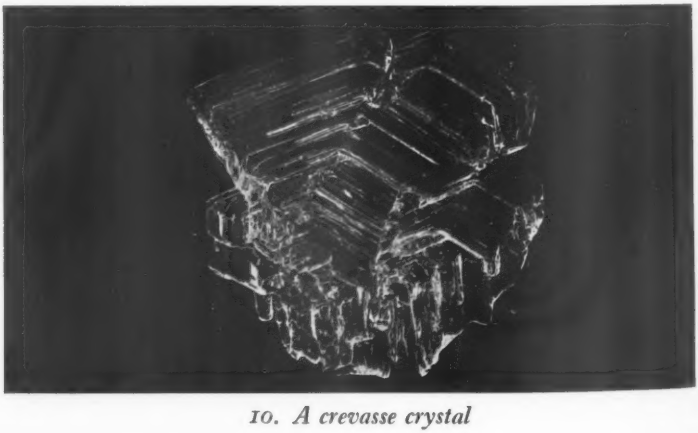
6. Undercut sastrugi

7. Icicles with flood-marks



8. Surface markings of an icicle

9. Icicles distorted by movement of crevasse walls



10. A crevasse crystal

system; they consist rather of elongated "lenses" of blue ice. And yet their origin must in some way be connected with the presence of wind crusts in their earlier stages, and at lower levels they develop into much more nearly horizontal layers.

When the first attempt was made to set up the station a pit was dug to a depth of 1·5 metres at a place a few miles from the site finally selected. To our discomfiture and astonishment it contained a 10-cm. layer of water at the bottom, although the air temperature was well below freezing and the season was advanced (September 8). If such water layers can percolate downwards in an irregular way, owing to relatively small irregularities in the intervening wind crusts, they may reach a temperature level where they become immobilized before they have time to spread out into level sheets again. Support is given to this rather extravagant hypothesis by several observations in the caverns at the central station, where narrow vertical columns of blue ice were found connecting horizontal blue bands with the ones below, although it

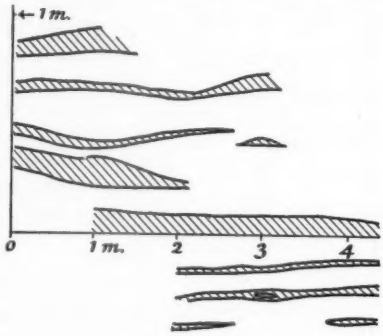


Figure 6. Blue bands in tunnel

still remains something of a mystery as to how such large quantities of water can make their way to these quite appreciable depths without apparently causing much alteration in the appearance of the layers above them.

The "firn stoss" as opposed to the surface "hush" was experienced in the evening of 27 November 1935, and again on 16 January and 5 February 1936, when the tent was appreciably shaken to the accompaniment of a rumbling noise which sounded as if it were approaching from a distance, reaching its loudest when the tent began to move and then quickly dying away again in the distance.

Contrary to the experience of Eismitte, Wegener's Greenland ice-cap station, we did not find any abnormal behaviour in the firn compression meters about this time; in fact they all recorded a perfectly steady compression throughout the whole of the time they were working. They were designed on the pattern of those described by Sorge and were specially built to be easily adjustable for height (Fig. 7) and yet strong and quite rigid, especially in the horizontal members that were to be frozen into the walls. With a magnifying lever with a 10 : 1 ratio the daily motion of the pointer was

just perceptible, and when plotted against time gives in each case a perfectly straight line. The values of the compression, using instruments about 1·5 metres long centred at depths of 1, 3, 7 metres, were $4{\cdot}00\times10^{-5}$, $1{\cdot}90\times10^{-5}$, and $3{\cdot}10\times10^{-5}$/day respectively. It is remarkable that the middle instrument should record the lowest rate. This must mean that at 3 metres the firn has become more rigid than at 1 metre, but on descending further the compression ratio again increases owing to the greater weight of the superincumbent layers. It is independent of temperature, which in the neighbourhood of the upper recorder changed from −2°·3 C. to −6°·6 C. between December and April. Using the ascertained values of ice-band and firn density to estimate the load above each indicator up to the mean surface level as 95, 190, 480 gr./sq. cm. respectively, the values of the stress producing unit compression per diem are $2{\cdot}33\times10^{9}$, $9{\cdot}81\times10^{9}$, $15{\cdot}19\times10^{9}$ dynes/sq. cm./day. That is to say, the ice-air complex becomes progressively *less* plastic with increasing depth.

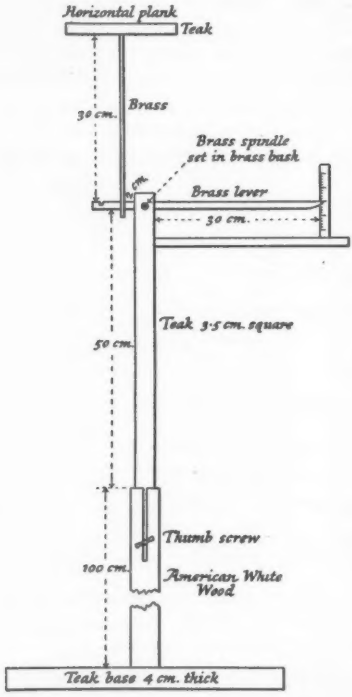


Figure 7. Firn compression meter

Density

The methods used in measuring densities of ice and firn varied according to circumstances. For snow and firn lying above the first blue band Seligman's 500-c.c. cylinder worked admirably as already described, apart from its inevitable disadvantage of slightly compressing samples of snow deposits of low density. With care in filling the cylinder this can be reduced to entirely negligible proportions. The most suitable cylinder was found to be the one with completely removable ends of the push-on type used on cocoa tins. It had only one small collapsible wire loop for attaching it to the steelyard, and when this was closed the cylinder could be gently inserted into the deposit until snow protruded from its outer end. This was trimmed off level with a skinning knife and the lids replaced after the cylinder had been dug out bodily from the drift.

Firn of relative density greater than 0·4 is too hard for the cylinder to be pushed into it and in any case it often occurred in layers which were narrower than the diameter of the cylinder, so that all that could be done was to dig out

a large piece which could be planed down with a sharp knife until it exactly fitted into a rectangular metal box $7 \times 5 \times 2$ cm. The error in this method is about 6 per cent. and values for samples from the same layer repeat to within this limit.

For ice bands a method depending on Archimedes' principle was used. Hexane remains liquid to a low temperature and is of a sufficiently low density for all ice samples to sink in it. Moreover it has two important advantages: being immiscible with water it at once disclosed any melting of the specimen during experiment, and since it has a very low ignition point it afforded a conclusive test to distinguish between true ice which contains separate air bubbles and very highly compressed firn which, although it presents much the same appearance to the eye, still contains interconnected air spaces. These spaces absorbed so much hexane that if one applied a light to a specimen after

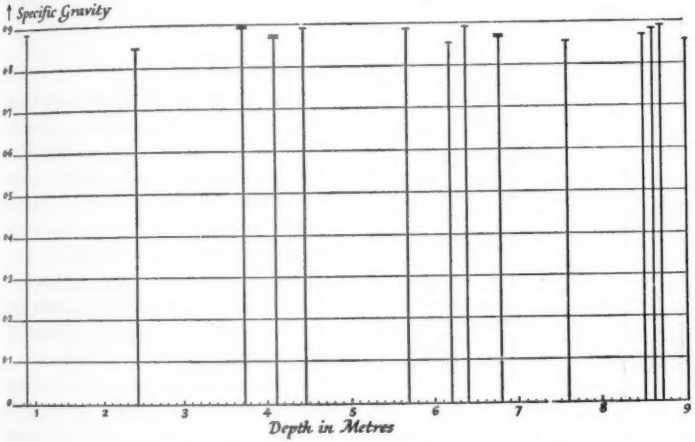


Figure 8. Density of blue ice from various depths

experiment it continued to burn until it had completely melted away, whereas the mere surface wetting of a piece of true ice was burned off in a few seconds.

While the relative density of the firn increased rather irregularly with depth from 0·35 near the upper blue band to 0·6 at a depth of 3 metres below it, that of the ice bands was practically constant between 0·85 and 0·90 (Fig. 8). The variations in density of the ice are however greater than the experimental error, for this method gives a relative accuracy better than 1 per cent., the absolute accuracy being somewhat less.

Now the region in which the compression ratio of 3×10^{-5} per diem was obtained consisted largely of blue ice bands. Thus if we take this as the order of the ratio for ice alone, the density of ice must increase by about 1 per cent. per annum, and, since the layers examined must have been in situ for many years, a readily detectable increase in density with depth towards the

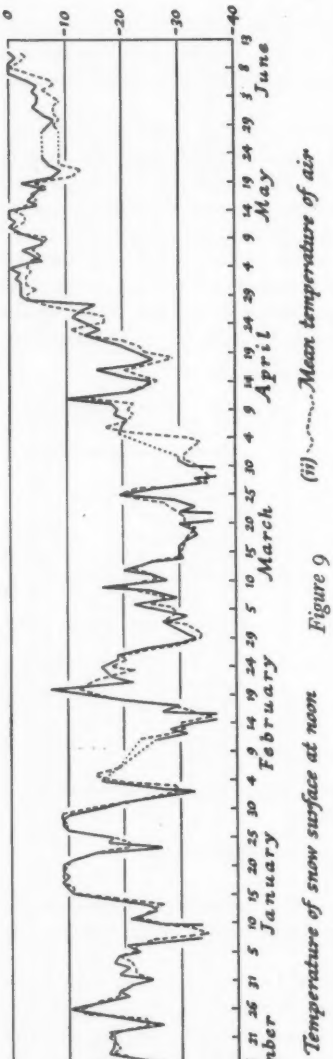


Figure 9

maximum possible of 0·92 would be expected. This is not found to be the case; and even more significant is the fact that nearly the greatest recorded density was that of a specimen from the uppermost layer. Thus we conclude that ice once formed remains permanently of much the same density, while the observed compression ratios are due almost entirely to consolidation of the firn bands, which gradually increase the thickness of the ice bands by a process of accretion until the whole forms a fairly homogeneous mass of ice at a depth of about 10 metres.

Temperatures

The temperature of the snow was taken at noon daily with an accurate mercury thermometer graduated to 0°·1 C. with its bulb placed 1 cm. below the surface. Values are plotted in Fig. 9, curve (i), which also shows the daily temperature of the air taken as the mean between extreme readings (curve (ii)). These curves keep very close together and the correlation coefficient between them is 0·99.

Temperatures at greater depths were ascertained in two ways. In the walls of the tunnels a series of horizontal holes was made at points whose vertical and horizontal co-ordinates, measured from a point on the junction of the snow and firn lines in the second vertical shaft (just below the letter "o" in the word "snow" in the diagram facing p. 213 in the *Journal* for September 1937), are given in Table I.

Sensitive mercury thermometers, with their bulbs enclosed in a cylinder of paraffin wax 8 cm. long by 2 cm. diameter so that their readings would not alter appreciably while being observed, were placed at the ends of the holes, which when possible

TABLE I

Number of thermometer	*Temperature in degrees Centigrade (negative)*			*Vertical co-ordinate measured downwards*	*Horizontal co-ordinate measured towards crevasse*
	Min.	*Max.*	*Mean*		
1	13·1	5·3	9·2	−0·14 metres	0·0 metres
2	8·5	3·5	6·0	0·39	0·0
3	6·7	2·8	4·7	1·01	0·0
4	6·6	2·3	4·5	1·33	0·75
5	3·2	1·3	2·3	2·55	−4·13
6	2·1	1·2	1·6	3·15	−4·13
7	2·1	1·2	1·3	3·30	1·80
8	2·4	0·5	1·5	3·66	3·03
9	1·9	0·7	1·1	4·12	3·49
10	1·4	0·4	0·8	4·84	4·70
11	1·0	0·2	0·6	5·42	5·54
12	0·8	0·1	0·5	5·86	6·55
13	0·5	0·1	0·3	7·16	5·13
14	0·4	0·0	0·2	7·82	3·89
15	0·1	0·0	0·1	8·55	1·95
A	1·9	1·6	—	3·15	−2·29
B	2·3	2·2	—	2·93	−5·83
C	1·9	1·8	—	2·93	−7·62
D	3·0	2·7	—	2·96	−11·53

were 2 metres long (owing to the difficulty of drilling the ice at greater depths this distance had to be reduced in a few cases). The open ends of the holes were stopped with cotton wool. This was only removed at 19 hours each day for reading the thermometers, which were withdrawn by means of stiff wires.

The readings of the four upper thermometers are shown in Fig. 10 and quite clearly illustrate the decrease in amplitude of the temperature waves with depth, each curve reproducing on a smaller scale the characteristics of the others. The connection between these and the surface temperatures is not so close (Fig. 9) although the general trends are the same. This is only to be expected since the distance between the surface and the lower thermometers is always varying.

Mean temperatures plotted against depth (Fig. 11) give an approximately exponential curve, but owing to the fact that there were not sufficient thermometers to furnish all the holes, and also that the holes were all drilled at very different dates as the shaft was dug downwards, the readings are not all exactly comparable and the error in the mean must be fairly large. However a logarithmic plot of these points gives a fairly good straight line (Fig. 11, curve ii) whose equation is

$$t = -10^{(0\cdot93 - 0\cdot215x)}$$

where t is the temperature in ° C. and x is the depth in metres.

It is arguable to what extent this equation represents the general tem-

perature distribution over the ice-cap, because this station can hardly be regarded as quite typical of the whole ice-cap owing to the presence of the crevasse described below. The thermometers A, B, C, and D were on approximately the same horizontal level, and although the figures given only refer to a short period of observation, they seem to indicate a horizontal as well as a vertical temperature gradient. This may however be a spurious effect due to the proximity of some of them to the main entrance trap door of the station. Also the daily readings of the shaft thermometers were in fair agreement with those taken once a fortnight by thermo-couples which had been placed permanently in bore holes made at the establishment of the station, and fortunately at distances from the crevasse different from those of the corresponding mercury thermometers, so that it is unlikely that the mean values are very far out. It certainly can be taken as well established that the temperature distribution in the North East Land ice-cap is very different from that in Greenland[1] and that its gradient is much steeper than calculated from Fjeldstad's formula.[2]

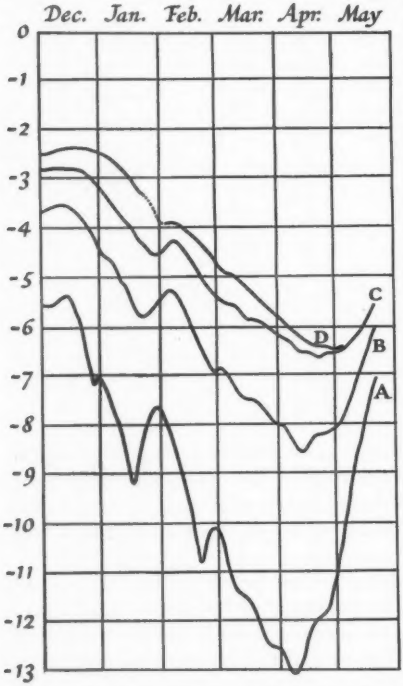


Figure 10. Temperature curves for various depths

Crevasse

On November 20 while work was being continued on the shaft, which had then reached a depth of 6·5 metres, a concealed crevasse was discovered. It was only a few inches wide at this level (it did not extend to the surface as in the *Journal*, 90 (1937) 213), and later when it was explored it was found to extend downwards to a depth of about 20 metres, growing wider and wider until it was 1–2 metres across at the bottom. It was divided horizontally into three almost separate galleries, whose floors were formed of large blocks of smooth ice with here and there cracks giving access to the lower ones. Each gallery was divided into a series of chambers by almost continuous curtains of icicles which had to be broken down before one could pass along to investigate in a horizontal direction. Over 100 metres of the crevasse were explored and it appeared to extend indefinitely in both directions.

[1] Koch and Wegener, *Medd. om Grøn.*, LXXV, p. 226.
[2] *Geog. Annaler*, XV, p. 314.

At the bottom was a stagnant pool of water 0·5 to 2 metres deep which remained liquid until May, when a layer of ice formed on top of it. On May 13 this was quite able to bear the weight of a 12-stone man, but by the 20th it had become thinner again so that at no place would it support 10 stone, and by June 9 there were many patches of unfrozen water again. There was no measurable change in the level of this pool, but evidently it had been higher in the past, judging by a series of perfectly level flood-marks that ran along all the walls, and which had sculptured what looked almost like architectural forms on a series of truncated icicles depending from the low roof of the gallery above (Plate 7). All these icicles ended on exactly the same level as the lowest flood-mark, which was 80 cm. above the present water-level. There were one or two icicles which extended farther, but without exception

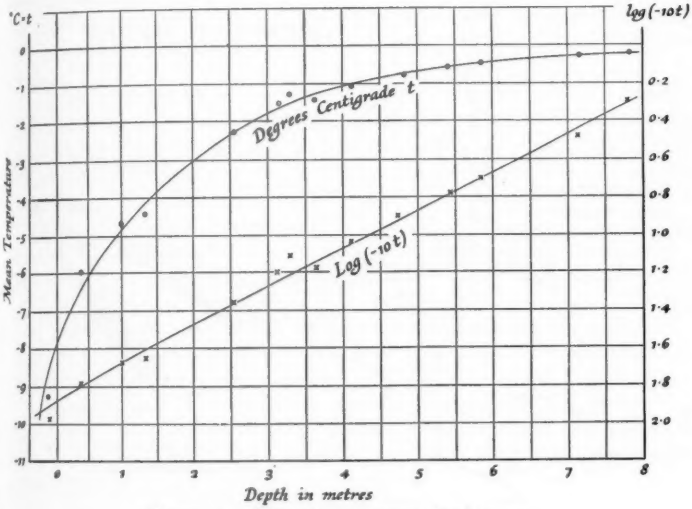


Figure 11. Mean temperature-depth curve

these did not display the rings of "sculpture"; in fact they were free of surface markings of any kind, suggesting that they were of recent growth.

The presence of icicles is a further confirmation of the hypothesis of the downward percolation of summer melt water through the upper layers of the firn, for there must have been at least 4 metres of snow between the top of the crevasse and the summer snow-level. They appeared to be of different ages, some having a deeply pitted surface with raised areas separated by lines 2–3 mm. deep. Plate 8 is a pencil rubbing of one of these. Other younger ones were quite smooth and all the intermediate types were represented. A number of the larger ones were attached to shelves of ice at both ends, and where these happened to be on opposite sides of the crevasse they showed unmistakable evidence of movement, while often thinner, smoother ones hanging vertically crossed them at quite an appreciable angle (Plate 9). The rate of widening of the crevasse was measured by a device working

on the same principle as the firn compression meter (Fig. 12); it was fixed horizontally and the levers kept in contact by a string carrying a lead weight at one end. The rate of movement was erratic: during May it averaged 0·08 mm. per day. Assuming that this rate has always been the same it would give the age of the crevasse to be of the order of thirty-five years.

Growing out of the walls and on some of the older icicles were ice crystals of unusual size. Plate 10 is a photograph of one, reduced by about one-tenth. Some of them were even bigger, reaching a length of 17 cm. This too argues a considerable age for the crevasse, for their rate of growth must be slow.

When the crevasse was first opened, and always after that time, a slight

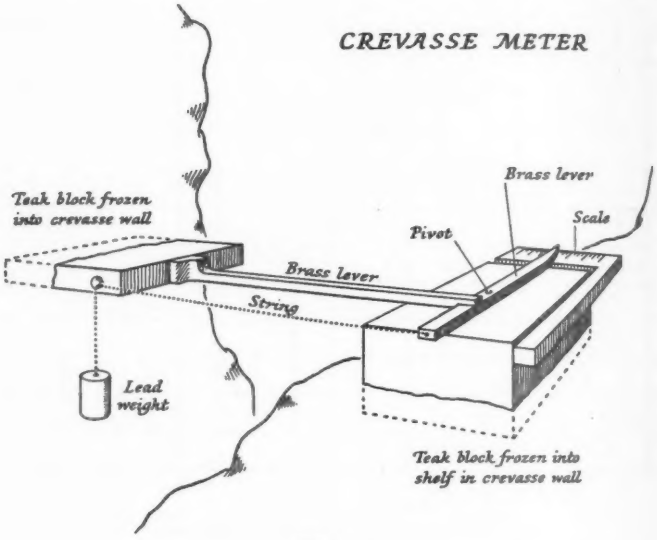


Figure 12

wind was noticed blowing out of it, usually strong enough to cause a candle flame to flicker. This was of considerable practical importance as it meant that the station was provided with an unfailing supply of fresh air, so that the consequences of the trapdoor being drifted over could not be as serious as they threatened to be when we were nearly asphyxiated early in November before the crevasse was opened. This draught appeared to be independent of the atmospheric pressure and therefore its origin must be looked for in the crevasse itself. It must be due to the escape of compressed air from the ice of the crevasse walls. An attempt was made to measure the air pressure of bubbles in the ice by the method described by Koch and Wegener, but our apparatus was hardly suitable, and it is only possible to state that it did not differ from that of the atmosphere by more than 15 per cent., which is a marked contrast to the value of 10 atmospheres obtained by them in specimens from

the Borg glacier. A small gas pressure gradient in the ice, or in the porous firn, would probably be sufficient to cause the observed draught, for the diffusion through the ice walls of the crevasse must be at work over a very large area.

Conclusion

Thus it seems that the North East Land glacier or ice-cap, although its surface details of supply and wastage are akin to the "high arctic" type, nevertheless resembles much more closely the alpine type, owing to its much higher mean temperature. For instance Koch and Wegener give a mean relative density of the ice as 0·911, whereas Mercanton working in the Alps finds 0·880, in close agreement with our value of 0·875. Correlated with this is the pressure of air in the bubbles. The depth of ice in North East Land is not sufficient to produce a compression comparable with that found in Greenland. It would be interesting to compare the densities of icebergs derived from these two sources.

The firn is stratified by somewhat irregular blue bands, which increase in thickness at the expense of the white firn until at a depth of 20 metres they are indistinguishable. The original production of these layers is associated with the percolation of melt water, and their subsequent growth must be largely controlled by the rather surprising temperature conditions within the body of the ice. Its distribution has been found but hardly accounts for the continuance of unfrozen water at a depth of 20 metres all the year round, for it must remain at least for very nearly that length of time because the latest date on which it could have been formed in 1935 was August 29, and on 9 June 1936 there was no sign of its becoming frozen through. It is hardly likely that it would do so in the month which intervened before the thaw took place on a large scale, thus supplying more water to the crevasse.

As the firn gets more and more deeply buried it becomes progressively less plastic, and in spite of the high temperature it would appear that the rate of motion of the main body of the ice-cap is extremely slow, thus agreeing with other evidence of its decadence.

DISCUSSION

Before the paper the CHAIRMAN (Admiral Sir WILLIAM GOODENOUGH) said: The interest of this afternoon's paper is considerable. If I tried to give a definition of physics I should raise a discussion in which the main part of the lecturer's researches would be lost. But for the benefit of those who do not follow these matters in detail I will read what the dictionary says: In current usage physics "is restricted to the sciences dealing with the properties of matter and energy or the action of different forms of energy on matter in general." Mr. Moss was, as you know, in North East Land. He will now give us a description of his experiences in connection with the physics of snow.

Mr. Moss then read the paper printed above, and a discussion followed.

Dr. T. G. LONGSTAFF (on taking the chair) said: I will ask Mr. Stephenson to add some remarks on this interesting paper.

Mr. STEPHENSON: I have been very interested in Mr. Moss's paper, and I must admit that I envy him his opportunity of being able to stay in one place for ten months and work at nothing but his own particular speciality. It must

be very satisfying to settle down, with no one but yourself to look after, and one definite line of work on which to concentrate.

There are one or two points in Mr. Moss's paper to which I should like to refer. First, as to the measurement of snowfall. This is extremely difficult, if not impossible, to measure at all accurately. As a result of his measurement, Mr. Moss decided that at least half the measured rise in snow-level was due to drift. This estimate is based on a comparison between the rise of level measured on the stakes and the total precipitation recorded by the snow gauge. I have not seen a Mougin snow gauge at work, but I suspect that a large proportion of the snowfall measured by the gauge is in itself drifted snow. Did Mr. Moss make any correction for this?

Mr. Moss: I think that Glen did make some estimate for this correction at the northern station. There is no doubt that a large part of the measured quantity is due to drift, and that therefore the gauge can only give an upper limit to the value of falling snow. That however is all I have assumed, and any correction will give a still larger discrepancy between the observed accumulation and that calculated from the records of the Mougin gauge. More information about the working of this gauge is necessary before anything definite can be said.

Mr. Stephenson: When the results of the Polar Year Expedition in Canada were worked out, it was assumed that the gauge could only give an upper limit to the value of falling snow. At Fort Rae we had a Helmann-Fuess snow gauge which gave a continuous automatic record of the snowfall, and at the same time we kept a careful hourly account, by visual observation, of the drift. We then deducted from the total amount recorded by the instrument the amount recorded during those hours in which we considered the snow that fell was drifted snow, and not true precipitation. As a result, our total recorded snowfall was very nearly halved and even that result was considered as being probably 10 or 20 per cent. in excess of the true amount.

Mr. Moss recorded by snow gauge a snowfall of 170 mm., and since no correction was made for drift, it seems probable that only about 100 mm. of this amount was due to true precipitation. This is equivalent to an increase in the height of the snow of about 30 cm., compared with a measured increase of 110 cm. In other words, over 70 per cent. of the annual increase consists of drifted snow, which seems at first sight to be rather excessive. Mr. Moss mentioned that hoar-frost and rime had been considered, and he concluded that deposition of this type was three times greater on the coast than inland. It seemed improbable however that the discrepancy in the measurement of snowfall could be attributed to this cause, since the discrepancy was evenly distributed over the ice-cap, and did not get greater towards the coast. This however is surely assuming that the wind force and drift were also uniform over the whole area? Might not the wind and drift be greater towards the edge of the ice-cap, as in Greenland?

Mr. Moss: As far as our observations extended, there was little variation in wind strength at different parts of the ice-cap; and it was, on the average, slightly less at the northern station, which was near the coast, than at the central one.[1]

Mr. Stephenson: It seems then that if frost deposition cannot be considered as a contributory factor to the 70 per cent. excess, there may be something misleading in the measurement by the stakes. Does Mr. Moss know of any possible correction that might have to be applied to these measurements? The paint on the stakes, I presume, did not cause any excessive radiation of heat?

[1] Hamilton, *Quart. Journ. Roy. Met. Soc.*, April 1938, p. 250.

Mr. Moss: The stakes were marked with 4-cm. bands of white paint alternating with 1-cm. bands of dark blue on one side of the stakes only. Evaporative ablation was not noticeably different near the different bands, and in any case if radiation from the stakes had been important, one would expect them to be surrounded by pits in the snow when this process had occurred, which was not, in fact, found to be the case. In addition to having the check stakes near the station we had flag staffs every quarter mile across the ice-cap. We could not of course visit these every day, but whenever we did their readings were in tolerably good agreement with those at the station.

Mr. Stephenson: With regard to the growth of the barchans, Mr. Moss mentioned that one thing necessary for their formation was a hard surface. Did they start absolutely from a plain surface, or was some nucleus necessary?

Mr. Moss: That I cannot say, because under the conditions when barchans occurred the snow surface was only under observation during short periods of the day (three observations of half an hour to one hour were made each day), so that the preliminary stages in the evolution of a barchan were never actually witnessed.

Mr. Stephenson: Concerning the relative humidity, could you tell us what instruments were used for this measurement, and whether you had simultaneous records from all your stations?

Mr. Moss: We used the ordinary wet-and-dry bulb, of the stationary and the whirling types, and also a recording hair hygrograph, but none of these records are very reliable. The instruments were read simultaneously at all three stations. The value of the relative humidity at the central station remained practically constant at over 90 per cent. On an exceptional occasion on May 14, when there was a large evaporative ablation under blue sky and warm sun, lowering the snow surface by 10 cm., the trace on the recorder dropped sharply to a value below 80 per cent.

Mr. Stephenson: In conclusion, I should like to congratulate Mr. Moss on the results he obtained during his isolation on the ice-cap, and on the interesting form in which he has presented them to us this afternoon.

Mr. G. Seligman: I had a few words with Mr. Moss before he commenced his lecture and he said that I would not find anything very interesting in it. I cannot agree. I have listened to one of the most interesting technical lectures I have ever heard, and I welcome it not only because of the intrinsic value of the work Mr. Moss has done but because it must be, if not the first, one of the first lectures to the Society dealing entirely with glaciological physics.

Since the days of Forbes and Tyndall, the physical investigation of glaciers in the field has, if I may say so, gone to sleep in this country. There have, of course, been exceptions. On Captain Scott's expedition glaciological problems were investigated very fully by Messrs. Wright and Priestley. But we have not kept abreast of other countries in our study of the subject and I do not see why we should be left behind. That is why I welcome Mr. Moss's work all the more because I believe it marks the resumption of the serious study of these problems by British expeditions.

As an example of the value of our getting as many people in all parts of the world as possible to study these problems, Mr. Moss observed in North East Land a kind of firn snow which he described to us as loose and granular. I have found exactly the same firn in the Alps and have described it as possessing a loose consistency like raw rice. I called it Dry Granular Firn Snow. It is interesting to find similar snow forms existing under probably quite different general atmospheric conditions in regions so many miles apart as the Alps and North East Land. If we can make our studies extend wider and wider over the world

we shall be able to get some kind of understanding of these problems. And there is no reason why we should not achieve this by our own efforts instead of relying on work done by other countries; in fact we have more opportunities for researches of this kind than almost any other country.

Mr. Moss's rather surprising remarks on drift were dealt with by Mr. Stephenson. I will not refer to that subject further. But on the question of the blue bands which Mr. Moss described in some detail—bands of blue solid ice interspersed with white firn snow and occurring at irregular levels right through the sections of snow which he cut—there is, I think, nothing so very fantastic in the suggestion that they may come from melt water; in fact, quite independently of Mr. Moss, I have formed the same idea, although so far I have not been able to prove that it is actually so.

You may have noticed one significant fact; the bands were all flat at the bottom and irregular or dome-shaped at the top. This seems to indicate that they formed as perfectly flat crusts, perhaps when that crust was at the surface. They then became covered up and gradually buried in the depths of the glacier. Surface water may then have percolated through the overlying snow until it reached the crusts. Now, although the firn snow is permeable to water, the crusts are not. So the water is dammed up upon them and may well give rise to the domed shape as it gradually collects and freezes on the top of the crusts. The bottoms, which the water cannot reach, retain the straight horizontal line of the original crusts.

I think that is the right solution of the problem. I hope so, because once we know how these bands in the higher névés are formed, much light can be thrown on another glacier problem. Blue bands of some kind are found again near the glacier tongues. If we have some idea how they are formed and what their internal structure is, it will help us to recognize their real nature in the tongue of the glacier and so to decide whether the latter are the identical bands which originally grew in the névé fields or whether they are a secondary product due to entirely different causes. This knowledge will throw valuable light on that most controversial of subjects, the nature of glacier motion.

Mr. Brian Roberts: There is one question I would like to ask Mr. Moss. Could he describe his method of boring holes in the ice?

Mr. Moss: We had two systems for temperature measurements. First, a system of vertical holes down which we put thermo-couples which checked up fairly well with the others. We used a system of ice drills built to specification sent out by Ahlmann but misinterpreted by an English mechanic, so that the cutting edge of the drill instead of being knife-edged was a $\frac{1}{4}$-inch edge; therefore it did not cut very speedily through ice. It might have cut through cold ice, but the ice we had to deal with was relatively warm and apparently melted under pressure, freezing up again in the teeth of the drill. The drill had therefore to be continually cleared of the solid deposit of ice which blocked the teeth, and to cut down to any depth was a lengthy process. Finally, we removed the cutting edge, took the 1-inch iron drilling rods, screwed them together and then beat them with a sledge-hammer until they went down. With them we were able to get down a long way.

For the ordinary mercury thermometers, which we used in the walls of the cavern, we drilled horizontal holes with the same drilling rods. They were about $1\frac{1}{4}$ inches in diameter. We hammered them into the walls with a sledge-hammer and screwed on a second one so that the depth of each hole from the side of the cavern was about 2 metres. In some cases it was a little more. Thus the readings of the thermometers will be slightly in error owing to the conduction of heat from the air in the passage. But as the whole temperature

of the ice-cap is so very high, and as the passage itself was very nearly at 0° C. all the time, I think the effect is very small, and using fortnightly values from the thermo-couples gives a close check. I think we can rely on the value of the temperature of the thermometers at least within a degree in each case. The general shape of the temperature curve is not very much in error. It is certainly very different from the one predicted on theoretical grounds.

Dr. LONGSTAFF: I have never previously heard of a snow barchan; generally they are associated with sand formations.

Mr. MOSS: I am afraid I know very little about the sand barchan; I gather it is very much the same shape as the snow barchan, although I am told that its evolution is different. In the report on Scott's Expedition there is just a mention of the snow barchan, and that is all I have read of them.

Mr. G. SELIGMAN: They have been described by Vaughan Cornish at quite considerable length.

Dr. LONGSTAFF: It falls to me as Chairman to thank the lecturer for his paper. The subject is a very difficult one and those who are interested in it will find, when his paper is published in the *Journal*, that it is fuller than the account to which we have listened. It is remarkable that out of such a difficult subject Mr. Moss could have given such an interesting lecture. It must indeed be surprising to many to learn of the high temperatures obtaining at so considerable a depth in an ice-cap at 80° N.

I ask you to join with me in thanking Mr. Moss very much indeed for having prepared and read a paper this afternoon.

THE COUNTRY BETWEEN THE HEADWATERS OF THE FLY AND SEPIK RIVERS IN NEW GUINEA

STUART CAMPBELL

Evening Meeting of the Society, 23 May 1938

AS in many parts of the world which are difficult of access, rumours have for many years been circulating as to the valuable mineral deposits which were likely to be found in the vast area of wild and unexplored mountainous country embracing the headwaters of the Fly and Sepik rivers in New Guinea, and it was with the purpose of investigating these rumours that the expedition here described was formed. This expedition was organized on behalf of American and British mining interests, and consisted of the following personnel: J. Ward Williams, leader; J. Burke, W. Kienzle, and W. Korn, prospectors; W. Brown, wireless operator and stores; R. Savage, aeroplane mechanic; and myself, pilot of the Sikorsky Amphibian. Later, when the work became too much for one aircraft, a second small machine was purchased and K. Garden engaged to fly it. In addition there were twenty-three coastal natives to act as carriers.

With a small expedition such as this, organized for the specific purpose of carrying out mining investigations, it will be realized that the time and opportunity for work of a purely scientific nature were strictly limited; and hence if the following notes appear to be incomplete in many respects, it must be remembered that they are all the result of spare-time work, and on a venture of this kind spare time is not so easily come by.

The Fly river was first ascended by L. M. D'Albertis, who in 1876, in the steamboat *Neva*, reached Palmer Junction and continued up the Palmer river to a few miles above its junction with the Tully. In 1890 Sir William Macgregor, then Governor of Papua, made the next explorations in this area, and by launch and whaleboat reached a point in the foothills of the mountains about 10 miles above the Hunter Twin islands. In his report on this expedition Sir William says:

"It was found possible to identify many places on D'Albertis' map as far as D'Albertis' Junction, but beyond that the course given to the Fly by him so little resembles the river that it appears to be purely diagrammatic and not to have been laid down from any traverse of the stream. Certain it is that not one point on it can now be identified, and consequently his farthest distance cannot by us be determined; but as it is quite impossible that he could have missed Macrossan Island had he ascended the river to that point, and as his steam launch could not have crossed the rapid there, which with a considerable rise of the river had for some distance only five feet of water at its greatest depth, it is quite plain that D'Albertis' steam launch never reached this island."[1]

In this assumption Sir William was undoubtedly wrong, since D'Albertis'

[1] Sir W. Macgregor: Despatch . . . giving details of an expedition undertaken to explore the course of the Fly river and some of its affluents. 1890.

map of the upper river corresponds substantially with his own, and both it and the accompanying report clearly show Macrossan island (which he called Small island), Palmer Junction, Surprise Creek, and Thompson Junction.

Several other Government and private expeditions carried out further exploration during the second decade of the present century, but their activities were mainly confined to the lower reaches of the river, and it was not until Austen made his patrols up the Ok Tedi and the Fly, in 1922 and 1924 respectively, that any real contribution was made to our knowledge of the country and its inhabitants in the area north and east of D'Albertis Junction. On his second expedition Austen ascended the Tully and crossed over to the Fly, and though he was unable, as he had hoped, to follow this river to its source, he brought back much valuable information both as to the topography and the geological formation of the country.

Three years later, in 1926–27, Karius and Champion, profiting by Austen's experience, attacked the limestone barrier by way of the headwaters of the Palmer river and made their epic crossing of New Guinea from south to north. This expedition finally correlated the headwaters of the Fly and the Sepik; in addition Karius added the Crystal river to the map, and Champion discovered the headwaters of the Fly and the picturesque little community of Bolowip.

In the meantime, on the northern side of the island, in what was then German New Guinea, exploration of a more scientific nature had been carried out with characteristic German thoroughness.

In 1910 an expedition formed for the purpose of surveying the German territorial boundary, and led by Dr. Leonhard Schultze, had ascended the Sepik as far as the Drei Zinnen in lat. 4° 48′ S., and this work was shortly followed up by Dr. Walter Behrmann, who in 1913–14 led a large and well organized expedition up as far as the Yellow river, and prepared a map of the Sepik river and the surrounding country which still ranks as probably the most accurate and detailed map ever made in New Guinea. From the base at the Yellow river one member of the party, Dr. Thurnwald, set off with only fourteen native carriers and made a most remarkable trek of over 100 miles through unknown country to the grass plateau of the upper Sepik valley, and thus achieved the distinction of being the first to discover the headwaters of the river. The records of this expedition have not, so far as I know, been published in English; Dr. Thurnwald's notes on the upper Sepik, taken from him at the outbreak of war, while he was still in the neighbourhood of the Yellow river, were returned to him a year later, after having suffered somewhat during their adventures.

From the above brief summary it will be seen that the country which we set out to investigate was to all intents and purposes virgin territory, and in fact by far the greater part over which we worked had never before been visited and only a very small proportion of the natives with whom we came in contact had ever seen a white man.

In the spring of 1935 we made our first aerial reconnaissances over the area and laid out a plan of campaign for the following year. On this first expedition, which entailed some 150 hours' flying, our work was largely confined to the

flat country and the foothills on the southern side of the dividing range. Transported by launch and by air, ground parties thoroughly investigated the Fly as far as Flint island, the Palmer river, the Ok Tedi, and the Strickland as far upstream as lat. 6° S., but only surface colours were found, and we turned our eyes towards the mountains. Several flights were made over the Hindenburg range and down the valley of the Sepik in search of some place where an aerodrome might be made, and as a result of these flights we decided that the grassy terraces of the upper Sepik valley offered the only suitable location from which to carry out further prospecting. The small aeroplane used on this expedition however was unsuitable for carrying large loads across these formidable mountains, and rather than remain there in idleness while another aeroplane was procured, the party returned to Australia, was reorganized, and set out again five months later with a Sikorsky Amphibian imported from America. Before dealing with the second expedition in detail, it will be necessary to describe the general topography of the country as ascertained from this preliminary work.

For over 600 miles from its mouth the Fly river winds a tortuous course across the huge flat alluvial plain of the Western Division of Papua, its banks fringed with dense tropical jungle, the only break in the monotony of which occurs in the mid-Fly area around Everill Junction, where the jungle is replaced by vast areas of swampy grasslands, broken up with numerous small lagoons and lakes, of which Lake Murray is perhaps the best known. At our base camp, 30 miles above D'Albertis Junction and 250 miles by air from the sea, the ground was less than 100 feet above sea-level, and between that camp and the coast I know of no rise in the country of more than about 200 feet.

The river is subject to frequent flooding, which is particularly noticeable in the upper reaches above D'Albertis Junction, and which ranges more than 30 feet between extreme high and extreme low water. These floods last from two days to a fortnight, and although they may, and do, occur at any time of the year, we found that they are most frequent from October to April.

Above Palmer Junction, which marks the limit of safe navigation for small power-driven craft, the river becomes more shallow and fast running, and its course is broken up by many sandbanks and small islands. The country now commences to rise, and at Flint island the river bed is 250 feet above sea-level. Hereafter we are among the foothills of the main ranges, and proceeding northward along the course of the river we meet with a series of razor-backed limestone ridges each a little higher than the last. At their lowest, where they are cut by the Fly river, these ridges run approximately east and west, but back from the river they rise and curve round toward the east-north-east and west-north-west. A mile above Austen's farthest point upstream is the largest of these ridges, which, though not more than 1000 feet above sea-level at the gorge through which the river passes, rises rapidly to 6000 feet on the eastern side, to what is presumably the Donaldson range.

Still farther north, a steep and rugged slope brings us within 3 miles to the summit of the Williams range, which, stretching across the country as a definite barrier, marks the beginning of the central mountain system. Through this barrier the Fly river has cut a narrow gorge over 1000 feet deep

and not more than 200 yards wide at the top. At this point the crest of the range is less than 3000 feet, but on either side of the gorge the ground slopes rapidly up to Mount Sare (8000 feet) on the east and Mount Austen (6000 feet) on the west.

Over the crest of this range the country again falls away: not as before, in a steep but gradual slope, but in one immense and almost perpendicular drop of nearly 1500 feet to the valley of the upper Fly. This huge basin, 15 miles from east to west, is bounded on either side by northerly spurs of the Williams range, while 10 miles away to the northward the mighty Hindenburg range rises in a series of sheer precipices, its crest nowhere less than 9000 feet and in places reaching over 11,000 feet. To the west this massive wall of rock loses its identity among the maze of rugged peaks which constitute the Star mountains, while at the eastern end of the valley it curves away to the north and becomes the Victor Emmanuel range. Fed by the perpetual mist and rain of these high altitudes, numerous small mountain streams rise on the slopes of the Hindenburg range and converge in the huge basin below to form the headwaters of the Fly river.

Within the valley we find a maze of small hills and ridges of which the most notable is the knife-edged Melokin range on the southern side of the Bol river, which, though attaining an altitude of 5000 feet, is in no way comparable to the formidable barriers of rock to the north and south.

Champion in 1926 had discovered the Feneng, Kinim, Amil, Inup, and Bol rivers, and from our reconnaissances we were able to add to the map the Kuub and the Ak Aup, several smaller unnamed streams, and a large confluent of the Feneng which rises some miles to the westward and drains the south-east slopes of the Star mountains. It is interesting to note that the headwaters of this confluent are separated by only a narrow ridge from those of the stream which enters the Ok Tedi from the north-east through the gorge observed by Austen in 1922.

Beyond the narrow crest of the Hindenburg range, in places little more than a mile in width, the country again falls away in a steep but uniform slope into the huge valley of the upper Sepik. After the monotony of the dense unbroken jungle which extends for hundreds of miles throughout the basin of the Fly river, nothing could present a greater contrast than this fertile valley, 20 miles long and 10 miles wide, with its gently rounded contours and its huge grassy terraces many square miles in extent, dotted here and there with numerous villages and native gardens, and completely enclosed by precipitous mountains. The two headwater streams of the Sepik, the Takin and the Lutap, rise at the eastern end of this valley and meander below their junction for some miles across the wide and thickly populated alluvial flats of the Feramin country. At the eastern end of the Behrmann hills they are joined by the Nunk, a tributary from the west which drains the blind valley between these hills and the Hindenburg range. Swinging northward to its junction with the Um, the Sepik enters a deep and narrow rocky channel close against the northern foot of the Behrmann hills and continues west-north-west for about 9 miles to its junction with another large tributary, the Ilim, which, rising beneath the 12,000-foot peak of Spica in the Star mountains, flows eastward through the centre of a wide open valley with grassy terraces on

either side. In the rocky channel the bed of the river is about 4000 feet above sea-level, and on the northern side the country rises to 4800 feet in a series of gently sloping grassy terraces which end abruptly in the once more heavily wooded and steep scarps of the Mittages mountains.

After being joined by the Ilim, the Sepik swings away to the north-west and leaves this great basin through a narrow gorge at the foot of a dome-shaped hill, and thereafter the nature of the country is entirely changed. The alluvial terraces and the grass disappear completely, the native villages are no longer seen, and for the next 40 miles, almost as far as the Brucken Junction, the river winds along the bottom of a narrow V-shaped valley with steep, jungle-covered hills rising to 7000 feet on either side, and not until Return Creek is reached are any signs of native habitation visible.

These huge grassy areas, the only grass country in thousands of square miles of dense jungle, raise an interesting question. Why are they in this valley only, and why do they cease the moment we leave it going north, south, east, or west? Dr. Behrmann has suggested that they are the result of intense native cultivation extending over a long period, but with this explanation it is difficult to agree. All our experience, both here and elsewhere in New Guinea, goes to show that when a garden has been abandoned, although at first some grass may spring up, it is rapidly choked and buried in secondary growth, and the land reverts to the jungle. The soil of these grassy areas is not suitable for cultivation, and moreover they are found high up on precipitous hillsides where it is impossible to imagine a garden ever having been located. One is tempted to suggest that the shallow soil and the impervious clay underlying it are unable to support the growth of large timber, but this is an unsatisfactory theory since we know of much dense jungle with big trees flourishing on what appears to be nothing more than bare limestone.

Past Return Creek the mountains on either side of the river become lower, the stream widens out and is broken up by numerous small flat islands and sandbanks, and between the Brucken and the Hoffnungs wide alluvial flats extend for a quarter of a mile on either side of the main stream. At the Hoffnungs Junction the river-bed is only 500 feet above sea-level, and here at the Zweifel gorge the last spur of the mountains is cut through and the river emerges on to the great plain through which it meanders to the sea over 500 miles away.

Returning now to the upper Sepik valley, and proceeding northward over the elevated plateau of terraces previously mentioned, we come to the Mittages mountains which, rising to 8000 feet, form the northern boundary of this great basin. Crossing this range we again descend into the narrow and well-populated valley of the Donner or Ok Elip, a tributary of the Sepik. At its eastern end this valley slopes steeply upward to a narrow north–south ridge, and, crossing over this divide, we come to the headwaters of another small river, the Om, which after an easterly course for about 25 miles is joined by another stream coming in from the north-east and then turns southward through a gorge between steep, grass-covered hills.

On the northern side of the Donner valley the Donner mountains form an ill-defined series of jungle-covered hills, and the grain of the country is no longer so apparent until the East river is reached, which flows along the

southern side of the Thurnwald range. This range, though neither so high nor so continuous as either the Williams or the Hindenburg ranges, runs as a definite entity from the Drei Zinnen in the west to its junction, 40 miles to the eastward, with the Central range.

The Thurnwald range marks the northern limit of the mountain area, and once over it we are on the watershed of the great northerly flowing tributaries of the Sepik: the May, the Frieda, and the Leonhard Schultze. Unlike the Papuan side however there is no sudden drop in elevation, and the mountains continue northward for another 30 or 40 miles, but although still precipitous and heavily wooded, they gradually become lower and finally disappear altogether in the great grass-covered, swampy plain of the middle Sepik.

Such then is a brief description of the country as we first saw it, and I will now describe the work carried out during the twelve months from May 1936 to April 1937 when we were in this vicinity. We had prospected the Ok Tedi, the Palmer, and a portion of the upper Fly on the previous expedition with no very promising results, and our primary object now was to establish ourselves on the grassy plateau of the upper Sepik, from which central point we hoped to be able to examine thoroughly a considerable area of virgin country to the north and west.

It was first proposed to fly over the mountains from our base on the Fly river and attempt a landing on one of the grassy areas mentioned above, but on inspecting them closely from a low altitude they were seen to be very wet, and the possibility of bogging the aeroplane and not being able to take off again was too great to be risked. It was obvious therefore that it would be necessary to send a ground party to walk over and select a site for an aerodrome, and the question arose as to which route they were to take.

The most difficult part of the walk would be the traverse of the precipitous Hindenburg range, and in view of this it was decided to make first for Bolowip, where on the experience of Karius and Champion we hoped to find the natives friendly and willing to act as guides across to the Sepik watershed. But how best to cross the Williams range and reach Bolowip was still a problem. Karius and Champion had worked up the Palmer into the foothill country round Mount Blucher and entered the upper Fly valley from the east, but a study of their report, and flights over the country, showed that this was both a long and difficult walk. The alternative was to go straight up the Fly, work along the top of the gorge, and then try to find some way down the limestone cliffs on the northern side. Here again, from Austen's experience, we knew that the route lay over jagged limestone all the way, but it had the merit of shortness, and once over the Williams range we hoped that a native guide would be found to lead the party to Bolowip.

The land party was to consist of Burke, Korn, Kienzle, and twenty-three coastal Kiwais as carriers, and to shorten the walk it was decided to establish an advanced base as far as practicable up the Fly. With this object in view, Korn and Kienzle set off in canoes with ten natives to select a site. Above Palmer junction the swift current and numerous sandbanks made travelling almost impossible, so instead of battling slowly up the Fly they carried on up the Palmer, ascended the narrow but more placid Tully as far as the canoes

would go, and then walked for seven hours due west to the Fly and made camp beside a straight stretch of water about 2 miles above Flint island.

Back at the base camp we had been visited almost daily by large numbers of Awins, Karwoks, and Ok Tedis, and had become so friendly with the latter that we decided to try to enlist some of them to augment the line of Kiwai carriers that was to make the trip over the mountains. We explained as best we could the difficulties of the journey and the hardships likely to be encountered, but despite this we had no lack of volunteers, and great was the disappointment among the remainder when ten only of the healthiest and strongest looking were finally selected.

All preparations being completed, Burke, the remainder of the Kiwais, the ten Ok Tedis, and all supplies for the trip were flown up in relays to the advanced camp, and after a small amount of repacking to better the distribution of the loads, everything was ready to start. The trip from the base to the advanced camp took ten days by canoe and walking, and only twenty-five minutes by air.

On 19 September 1936 the party moved off on their long trail into the unknown, and though the story of that walk will, I hope, one day be written, it is not intended to deal with it here except in its relation to the expedition as a whole. It had been arranged that I should make contact with them from the air on their arrival at Bolowip, when by prearranged signals they would be able to indicate if they required any additional food or other supplies; and further, we were to fly up the track to Bolowip daily on the off-chance of being able to locate their camp of the previous night and so keep in touch with their progress. The heavy canopy of jungle however made air observation almost impossible, and though on the seventh day I did catch sight of a small camp clearing perched on the very lip of the gorge, that was the only indication we had of their whereabouts until nine days later, when Williams and I flew over and located them in the village square of Bolowip, with the sign out to indicate that all was well, but they needed more rice. We had anticipated this request, and circling round the village we threw out four 30-lb. bags, but unfortunately we were not then experienced in supply-dropping, and could see that at least three bags landed some distance from the village in a small rocky ravine where there would be little chance of finding them. We estimated that about another 200 lb. would be required, returned to the base camp, refuelled, and set off with further supplies.

Little over one and a half hours had elapsed between the time we left Bolowip and when we again crossed the Williams range on the second trip, but in that short time there had been a marked change in the weather. The upper Fly valley was rapidly filling with clouds, and on reaching the junction on the Bol and the Feneng I found that to get to Bolowip it would be necessary to fly low along the narrow valley of the Bol beneath a heavy layer of gradually descending cloud. If the valley filled in while I was at Bolowip there would be no possible way out, so I decided to return home and have another attempt next day. Bad weather now set in, and for the next six days we made two trips a day up to the mountains, but on every occasion the whole valley north of the Williams range was completely filled with clouds, and it was not until the fourteenth attempt that we managed to reach Bolowip, only to find that

Construction of hangar at the Fly river

Camp and aerodrome on the Fly river above D'Albertis' Junction

Hangar on the banks of the Fly river

The Mittages mountains with the cloud-filled valley of the Om

The junction of the Sepik and the Ilim at the foot of Kahlkopf

the land party had gone. This was very disturbing, as we had no idea whether they had pushed forward on short rations over the Hindenburg range or, thinking perhaps that something had happened to the plane, had decided to return to the base camp.

For two days we searched the course of the Fly river without success, and then on the third morning, finding that the clouds had partly cleared from off the main range, we flew through a small opening over the top and across to the sunlit valley of the upper Sepik. Here for half an hour we searched the grassy terraces and the villages, hoping to see them, and yet realizing how easily we might miss them in that huge area. We were on the point of returning, when far up on the northern slope of the range we saw a dense cloud of smoke, and flying over to investigate we saw the tents pitched on a small grassy ledge and the signal out for more food. We dropped 100 lb. of rice, our aim being better this time, and after seeing it all recovered we climbed away home very much relieved.

From then onward the ground party made good progress across to the northern side of the valley, and October 20 found them established on the grassy plateau and commencing to burn off a site for an aerodrome. It was by no means a natural aerodrome, but after six days of digging out boulders and stumps they gave me the all-clear signal and I made the first landing at the head of the Sepik on a narrow strip of ground 40 yards wide, 400 yards long, and sloping uphill at an angle of about 1 in 20. As can well be imagined, it was a very happy reunion on that aerodrome, and there we learned how very nearly the long period of bad weather had upset our carefully laid plans.

All had gone well with the ground party until past the Williams range, the northern face of which they were able to negotiate by scrambling down a steep creek-bed close up against the eastern wall of the gorge; but once in the upper Fly valley they turned eastward too early, mistaking the Kuub for the Bol, and then for two days they struggled through trackless jungle, hopelessly lost and ever striving to make north and east to where they thought Bolowip must lie. Toward the end of the second day they made contact with some natives who, although at first terrified, were gradually won over and persuaded to guide the party to Bolowip, which they reached about an hour before we sighted them from the air.

This portion of the journey had taken longer than was expected and their rice was beginning to run low, so after collecting the one 30-lb. bag which they were able to find they waited hopefully for more. When the bad weather set in however the situation became critical, and as is always the case in New Guinea, food for the carriers was the difficulty. With a big line of boys such as they had, eating about 50 lb. of rice a day, they could not afford to remain idle for long, and so after waiting for two days they bought all the taro that could be obtained in the village and courageously decided to push on over the mountains, although they were by no means fully supplied for the journey.

As had been hoped, several of the Bolowips agreed to go as guides and led the party away east-north-east from Bolowip toward the headwaters of the Bol, to where the great rocky scarp of Mount Faim rises at an angle of about 50 degrees from 5000 feet to 10,000 feet. All that day they climbed upward, blinded by thick mist and torrential rain, but at last the summit was reached,

and here camp was made. The carriers, numbed by the cold and exhausted by the strenuous climbing and the rarefied air of the unaccustomed altitudes, were showing signs of acute distress. Only fifteen of the thirty-three boys reached camp that day; the others stopped exhausted by the track, slept out in the wet bush all night, and came staggering in next morning so weak that it was decided to remain there for the rest of the day. So rigorous had been that climb that, rather than walk farther, they chose to remain in camp for a whole day in the bitterly cold rain among the stunted moss forest of the New Guinea highlands at an altitude of 10,000 feet, and this although their food supplies were getting dangerously low and they had not heard anything of the aeroplane for four days.

Refreshed by their rest, the party set off again on October 10. Five of the carriers were still sick; one of these could walk only with the aid of sticks, and two more were being carried on the backs of the hardy and friendly Bolowips. The track still lay upward, and that day they climbed over the summit of Mount Effel (11,000 feet), the highest point reached on their journey. At daylight on the following day they moved off again to north-north-west along the ridge of Mount Effel, and that night they camped where, the Bolowips told them, Karius and Champion had camped nearly ten years before.

Next morning at 9 a.m. they began to descend, and two hours later, from an altitude of about 8000 feet, they had their first glimpse of the valley of the upper Sepik. The towering cliffs and the jagged, moss-covered limestone lay behind them, they were on a steep but easy downhill grade, and stretched out at their feet lay this huge grassy valley, a Promised Land indeed and a sight to cheer them on after their heroic struggle over the backbone of New Guinea. They climbed wearily down to a small grassy ledge at 7000 feet, and made camp to rest and to take stock of the situation. They had crossed the mountains and their goal was in sight, but their worries were by no means over. There was only two days' food left, and they had neither seen nor heard anything of the aeroplane since they had first arrived at Bolowip six days before. If any accident had occurred, then their position was indeed serious.

Their Bolowip friends assured them that plenty of food would be obtainable from the Feramin people in whose district they now were, but although soon after their camp had been made a number of these tribesmen appeared and sold them a young pig and a small amount of taro, they did not stay long and no further visitors arrived. All the next day the party rested in camp, but no more natives were seen and it became evident that they would not be able to rely on procuring any great quantity of native food.

The Bolowips now indicated that they were anxious to be getting home, and it was decided that if the aeroplane did not show up on the third day Kienzle and five of the fittest of the carriers would have to accompany them back to Bolowip, and then make their way across the Williams range to the low country, raft down the Fly river to the base camp, and somehow send help. In the meantime Korn and Burke would remain in camp with the rest of the carriers and endeavour to establish friendly trading relations with the Feramin. It was a grim outlook for Kienzle, as well as for Korn and Burke, but the position was critical and something drastic had to be done.

At noon on the third day they heard the welcome sound of the aeroplane

and they knew that their worries were over and their line of communication was still intact. After collecting the food that we dropped them they set off on the trail again, and after three days of fairly easy travelling along native tracks made camp on the grassy plateau on the northern side of the valley and began to look about for a suitable aerodrome site.

As we had anticipated from our earlier reconnaissance flights a year before, these grassy plains were by no means ideal for a landing field. They were thickly strewn with limestone boulders, and in addition the drainage from the Mittages mountains, which is unable to penetrate the hard clayey subsoil, keeps the few inches of surface loam permanently wet and boggy. Even in comparatively dry weather the surface water lies in semi-stagnant pools in the hollows between the roots of the short, tussocky alpine grass. At several places there are small ridges, raised a foot or so above the level of the surrounding ground, and on one of these the landing strip was finally marked out. Even on this ridge however after rain the surface soil would remain saturated for several days, and landings and take-offs would necessarily be made to the accompaniment of showers of mud and frequently dangerous skidding.

Immediately after the first landing, petrol and other stores were flown over from the Fly river, and a permanent camp established close beside the aerodrome. From this camp we carried out all our exploration, both on foot and by air, for the ensuing five months.

While the stores were being flown over, Korn and Burke made several small excursions over the plateau in the neighbourhood of the camp. All the small mountain torrents flowing into the Sepik were prospected and pits were sunk to 15 feet in the terraces themselves, but the wash was mainly limestone and sandstone gravels, and within a week it became evident that this great valley of the upper Sepik, the El Dorado for so long of all miners and prospectors in New Guinea, was barren of gold.

We determined to move farther afield, and to view the lie of the land made several reconnaissance flights to the country northward on the other side of the Mittages mountains. For some days the clouds hung low in the valleys, but on November 1, with Williams, I flew down the Sepik to the Donner, followed the latter to its source, and crossing a narrow north–south divide at about 7000 feet we found ourselves over the headwaters of another and hitherto unmapped stream flowing away to the east. This, at first we thought, must be the Leonhard Schultze, but following it eastward along a deep and narrow valley for about 20 miles we found that after being joined by another fairly large stream coming in from the east it swung south through a grassy gorge. A slight engine defect prevented us from carrying on, and at no subsequent time did we have the opportunity of tracing the course of this river farther, but there would seem to be little doubt that the Om, as it is called by the local natives, can be nothing else than the upper reaches of the Crystal river, a confluent of the Strickland discovered by Karius in 1927. This means, as Karius suspected, that the Strickland actually rises on the northern side of the Victor Emmanuel range, and drains a considerable area of country on the northern slopes of the central mountain system.

As a result of this reconnaissance, plans were immediately made to examine this country more closely, and on November 14 Williams, Burke, and Korn

set out from the camp with sixteen carriers to explore these rivers on foot. Native guides from the Sepik valley led them up a steep and dangerous trail to the summit of the Mittages mountains, and along the crest of this range they walked eastward until they came to the narrow divide separating the Donner and the Om. Descending into the valley of the Om, they rapidly lost altitude to 3000 feet. Some sago was seen, the first since Bolowip, and game was plentiful, but natives few. This, their guides told them, was the country of the Omtamin, and farther downstream at the junction of the two rivers lived an enemy tribe, the Suarmin.

For three days they followed the stream, prospecting as they went, but though some "colours" were found, the gold was too finely disseminated throughout the prevailing limestone gravel to be workable. Along the sides of the valley, where landslides had denuded the covering of jungle and laid bare the strata, many thick beds of black shale were observed studded with magnificent ammonites. The strike of these beds lay roughly east and west, and they were frequently traversed by fine seams of quartz which however did not appear to be auriferous. Deciding that an El Dorado lay not in this valley, the prospectors retraced their steps and crossed over the ridge into the valley of the Donner. Here the same conditions and type of country were encountered, and after a brief examination of the gravel banks for some few miles downstream, they once more scaled the Mittages mountains and returned to camp.

Nine days later Korn and Burke set out again and carried out a thorough examination of the Sepik and its numerous small tributaries as far downstream as Return Creek, but the white limestone showed up clearly in the bed of the river at low water, and no gold was found. It became clear that this limestone belt extended much farther north than we had originally suspected, and if we were to achieve any success we should have to move much farther afield.

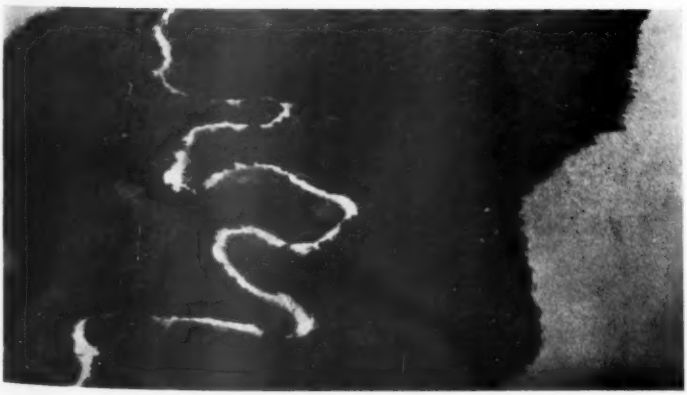
We had not enough carriers to go northward over the Thurnwald range, and our friends of the upper Sepik told us that in this direction, at the head of the May, we should encounter the savage and hostile Mianmin. Our way must lie down the Sepik, and this route had the advantage that if somewhere downstream we could locate a stretch of water where the aircraft could alight, much time and heavy walking would be saved by flying the party down in relays. Flights were made down the Sepik almost as far as the Hollander river, but the main stream was too swift and its bed too broken to afford any hope of a successful alighting.

Opposite the Hoffnungs Junction we observed a small stream flowing parallel to the Sepik and separated from it by a low ridge not more than a mile wide, and this unmapped stream, though narrow and fairly fast, could, we thought, be used for alighting with a fair chance of success. We decided therefore to fly the party down and leave them on the shores of this creek, which we called the January river, from which point they would be able to prospect the Brucken, the Hoffnungs, and a large area of mountain country to the north of the Sepik.

The district we now proposed to enter had never before been visited, and as it was a long way from our base camp in the mountains we could not isolate a party there and leave them dependent on one aeroplane. So we decided

Looking south from the Sepik camp over the Behrmann hills and the Hindenburg range

May river near the junction of the west and south-west branches



The Screw river, middle Sepik

Head adornment of a Kiarikim

Telifomin style of hairdressing

to purchase a small land plane, and after this had been flown up from Lae by K. Garden the move began. But after Korn and Burke and two carriers had been put ashore on a small island in the January river, both aircraft were damaged while landing in bad weather at the mountain camp, and the rest of the move had to be made on foot. Kienzle with twelve carriers made a remarkably rapid journey of twelve days down the rugged valley of the Sepik to the Hoffnungs, and joined Burke and Korn; and as by this time we had been able to repair both aircraft, supplies were flown down and the work continued according to plan.

Both the Brucken and the Hoffnungs proved disappointing. The river beds were full of limestone gravel and black shale, and no gold was found. In the January some good prospects were obtained in the surface wash, and though the "colours" disappeared completely at 2 feet, it gave us hope that we were in the right area at last. From the air I traced the headwaters of this stream and found that one branch rises well to the east and flows along the northern foot of the Thurnwald range, while the other comes from the north-east and drains the southern slopes of the Blauberg mountains. The Thurnwald range, we knew, was largely limestone, and hence we had little hope of finding gold in the eastern tributary. It was decided that a land party should follow the north-eastern branch to its source and then, if no success had been achieved, cross over the north–south divide into the basin of the May and cut across all the tributaries flowing into this river above the farthest point upstream reached by Dr. Behrmann in 1913.

On 23 February 1937 the party, consisting of Williams, Korn, and Burke with fourteen native carriers, set out from Wednesday island, as we had named the small island in the January where our camp had been established, and made fairly rapid travelling until they reached the head of the river. Near this they met the first natives since leaving the Sepik plateau; though at first aggressive they were finally induced to trade taro for beads and small knives. But they evidently resented the intrusion. No payable gold had been found, and the party pushed on over the ridge and on to the watershed of the May river.

Crossing the divide at about 5000 feet, Williams and his party found themselves in terribly rough trackless country in which there was not even enough flat ground to make camp. Steep razor-backed ridges interspersed with narrow ravines criss-crossed in all directions, and frequently wooden platforms had to be built out from the sides of the hills so that the tents could be pitched at night. In this country communication with the aeroplane was difficult, and on more than one occasion they were down to their last meal before they found a flat area of ground of sufficient size to allow further supplies to be dropped from the air.

On March 10 they reached a point where the stream appeared to be deep enough for rafting, but the current proved too swift and the rafts were dashed against snags and capsized, and much of their valuable gear was lost. Slowly they worked downstream toward the flat country, and on March 17 reached a long smooth stretch of water below the confluence of the west and south-west branches of the river. Here I alighted in the Sikorsky, and a permanent camp was established only 500 feet above sea-level. A mile or so upstream the river divided into three branches: the one down which they had come, from the

south-west, one from the west, and one from the north-west. The numerous headwaters of the south-west branch rise in the low rugged mountains north of the Thurnwald range, and after winding for many miles through a maze of deep and narrow ravines between steeply sloping hillsides, finally pass out on to the huge flat alluvial plain to the east of the Bergsturz range. The west and north-west branches, rising respectively in the Bergsturz and West ranges, rapidly lose altitude and flow between low and heavily wooded banks to their junction at the eastern end of this alluvial basin.

Prospecting had been carried out all along the route, and some promising results had been obtained on the eastern side of the divide. A hand drill was flown over and a number of holes put down in the sandstone gravels along the course of the river, but again the gold proved to be only a surface deposit. Excursions were made upstream, and the flat country through which these streams flow was systematically tested, but without result. Downstream at the junction of the southern branch the limestone was again encountered, and with this our last hope faded away. We had thoroughly examined the whole of the Sepik basin as far as the Hoffnungs river, and the upper waters of the May above the farthest point reached by Dr. Behrmann, and our results showed that in the whole of this area, covering many thousands of square miles, there was no payable deposit of alluvial gold. We had completed the work we set out to do, and it only remained to evacuate the mountain area and fly the party back to the base camp in relays. On June 28 the Sikorsky took off for the last time from the May river, climbed through clouds to 15,000 feet, crossed the Hindenburg range, and, alighting at the base camp on the Fly river, brought to a close another chapter in the history of New Guinea exploration.

The mountain people

From the mouth of the Fly the coastal area extends to about lat. 8° 20′ S., and there habitation appears to cease abruptly. No villages and few wandering natives are seen until one reaches the grassy swamplands of the mid-Fly. Here there are the Suki and Lake Murray people, whose habits and mode of living bear little resemblance to those of the Kiwai and Gogadara of the estuary. Continuing northward and leaving the grass country behind, one notices that habitation again becomes more scarce, and upstream from about lat. 6° 50′ there is another "no man's land" which continues until a short distance above Raggi island, where we met with the first of the tree-dwelling people, distinct in every way from the inhabitants of the mid-Fly.

These people appear to be divided up into three fairly well defined groups: Karwoks, inhabiting the country south of D'Albertis Junction and the southern bank of the Fly almost as far as the Elevala river; Ok Tedis, inhabiting the western bank of the Ok Tedi river; and the Awin, the most numerous tribe of all, whose villages are found east from the Ok Tedi almost as far as the Strickland and well up into the foothills of the Williams range.

First described by D'Albertis, these people have been further studied by Macgregor and Austen, and though there is some suggestion that they are not all of the same race, their habits and dress are sufficiently similar to allow them to be grouped as the plain-country people of the upper Fly. The

Kiarikmin shield

A Kiarikmin woman

Kiarikmin village in the upper Sepik valley

"Iol um" in a Telifomin village

Williams range forms their northern boundary, and once over it, in the valley of the upper Fly, we encounter the first of the mountain people, a race which, though divided into numerous small communities, exists as a definite entity from the Williams range on the south to the Thurnwald on the north, and from the border of Dutch New Guinea to at least as far east as the Strickland. With this strange and little-known group of people the following notes are concerned.

Although there can be little doubt that these mountain people have a common origin, they are now spread over a wide area, each little tribe or village with its own territory, and keeping strictly to it except for trading excursions to neighbouring friendly tribes. Between the Williams and the Hindenburg ranges live the Bolowip, the Feneng Kiak, the Fairolmin, the Brakelmin, and probably many other tribes which we did not touch, while to the east Karius has reported the Unkiamin and the Setaminmin in the valleys of the Wungop and Luap respectively. Northward of the Hindenburg range, in the valley of the upper Sepik, we find the Feramin inhabiting the country near the junction of the Takin and Lutap, and in the middle of the valley on the grassy plateaus there are many tribes which may conveniently be called the Telifomin group. Within this group we find the Kiarikmin, the Ulapmin, the Boelmin, the Koblenmin, the Filindiwip, the Atem Kiak, and the Telifomin proper, and though each tribe is jealous of its separate entity, there is some evidence that they are all offshoots from and owe some allegiance to the Telifomin tribe, which is undoubtedly the most powerful in this section of the valley.

Among these people our mountain camp was established, and the following notes refer in particular to them, but in general to all the mountain people from the Williams range to the Thurnwald. Westward, in the valley of the Ilim, live the Tifalmin and the Atbalmin, and on the other side of the Sepik, in the valley of the Fek, the Fekelmin. Crossing the Mittages mountains into the valley of the Donner, we find the Eliptamin; at the headwaters of the Om, the Omtamin; and farther downstream on this same river, the Suarmin.

On the northern side of the Thurnwald range, we are told, live the fierce and warlike Mianmins, and though probably they too belong to the same race, we encountered them on only one occasion, and cannot speak with any certainty. Nor do we know anything of the inhabitants of the thickly populated Brucken valley; and our contact with the natives at the head of the January and May rivers was so brief that we can record only a general resemblance to the people of the upper Sepik.

Shut away in these wild and rugged mountains, and surrounded by enemies of their own kin, these isolated little groups seldom travel far from their own territory and can have little direct contact with the remainder of New Guinea. Some intercourse with the plain-country people of the upper Fly certainly takes place in the foothill country near Mount Blucher, and there is evidence of another trade route at the western end of the Williams range near the headwaters of the Ok Tedi. To the north, the uninhabited area between the Donner mountains and the Thurnwald range is seldom if ever traversed, and towards the west the barren peaks of the Star mountains are almost impassable. To the eastward we know of trade relations with the Suarmin, whence, we are

told, come the small white cowrie shells, less than a quarter of an inch long, which are made up into forehead bands and highly treasured. These shells and the crescents of mother-of-pearl shell described by Karius from Bolowip are very much like those worn by the natives of Bena Bena and Mount Hagen.

All the mountain people, like the plain-country people of the upper Fly, are self-professed cannibals and make no secret of the fact that enemies slain in battle are eaten. Every tribe is at enmity with some of its immediate neighbours, though conflicts seem to be few and probably only occur when two small hunting parties meet near the inter-tribal boundary. The origin of these hostilities is obscure, but our observations suggest that arguments over hunting grounds or garden areas were the original cause. They are not mere passing disputes, for the enmity between the Bolowip and the Fairolmin, reported by Champion in 1926, still exists. The following is an example of complicated inter-tribal relations in this mountain area. The Telifomin group are at war with the Feramin and the Tifalmin peoples, but are friendly with the Bolowips and the Fairolmins of the upper Fly valley. The Bolowips are friendly with the Feramins, through whose country they come when visiting the Telifomin group, and the Fairolmins mingle freely with their friends the Tifalmins on their way to or from the Telifomin country. There is great enmity between the Bolowips and the Fairolmins, but what would happen if a Bolowip met a Fairolmin, both far away from their homes, in the territory of their mutual friends the Telifomin, we were unable to discover.

Despite the continuous talk of fighting, and the frequent bloodthirsty pantomime depicting the fate of an enemy who should fall into their hands, these mountain people are essentially a happy and peaceful race, living an idyllic life in the healthy, bracing mountain climate. They are short, about 5 feet 2 inches, lightly built, with no great physical strength, but their resistance to extreme cold and altitude is truly remarkable. On trading visits they frequently camp at 8000 feet, and here, in the clammy mountain mist only a few degrees above freezing, they will lie in the wet bush beside a few smouldering embers and sleep through the night with no covering of any kind.

They are, in the main, uniformly dark brown, lighter than the coastal Kiwai of the Fly estuary; but many variations occur, and a light copper colour is not uncommon among the Fairolmin. Their hair, when not elaborately made up, is black and tightly curled; and bushy beards, the sign of manhood, are desired by all males. I do not feel qualified to discuss their features and of their disposition I can only say that they are the most friendly, happy, and unsophisticated people it has ever been my good fortune to meet. Of sickness or disease, except perhaps anchylostomiasis, there appears to be none, and it is indeed delightful to see a whole community entirely free from the unsightly skin diseases so prevalent elsewhere in New Guinea.

Clothing is absent, but there is much and varied body decoration. We found no evidence of any distinction between the married and unmarried, either in adornment or in any other way. The most elaborate decorations are in the coiffures, of which there are several varieties, but although one style might be favoured in one village, there was no uniformity, and we could discover no reason for the adoption of any one of the standard forms. Youths below the age of puberty, young girls, and women invariably wear the hair

either close-cropped or short round the sides with a tuft on the crown of the head, and this style is also frequent among the older men. As a variation, commonly adopted by young men both single and married, the central tuft is sometimes made into a bundle and wrapped round with a string net held in place by pins made from the small bones of a cus-cus; a bunch of feathers in the top of this conical pile completes the decoration.

A more elaborate coiffure, worn by young and old men alike, is made by taking tufts of hair and carefully wrapping them round with grass to form small ringlets, which are then brought together at the back into a long, stiff tapering tail wrapped round with native string and painted red. One or two pieces of thin rattan about 2 feet long are sometimes fixed in the end of this, and curl round, pointing toward the front, about on a level with the wearer's knees. Two of these tails are usually worn; the smaller is made from the hair at the front of the head and lies on top of the larger. Instead of the long, tapered carrot-like tail, the grass-wrapped tufts of hair may be brought together into a thick cylindrical one ending in a turnip-shaped bulb 3 to 6 inches in diameter. The hair from the front of the head is made up into a small tail of the same shape which lies on top of the larger one. There is another less common variation with two flat, spatula-shaped tails lying one on top of the other.

In addition to the coiffure, a band of long cassowary plumes is commonly worn across the forehead, falling back over the crown of the head. A string of short cassowary or bush fowl feathers, or occasionally dogs' teeth, is sometimes worn round the base of the hair with the plumes or teeth sticking out horizontally like a halo. These strings of short feathers may also be used as a false beard extending from ear to ear. Two highly prized decorations only possessed by the older men, and seldom worn, are the forehead band of small parrot feathers and a band with one or two rows of the very small cowrie shells such as are met with in the Mount Hagen district. Forehead bands of Job's tears are frequent, and sometimes a small band of skin about a quarter of an inch wide, taken from the underside of a cus-cus' tail, is worn just above the eyes.

As in many parts of New Guinea, the septum of the nose is pierced, and a pig's tusk or a short piece of bamboo worn in it; the nostrils are often pierced at the sides and in front to take the horns of the rhinoceros beetle, long cassowary quills, or short stubs of very small bamboo. The lobe of the ear is pierced to carry the short length of bamboo containing the red dye used for decorating arrows. We noticed that it was almost always the left ear that was pierced, and found the reason to be that most men are right-handed, and there is a danger of this dangling bamboo fouling the bowstring if worn in the right ear. Most women have their ears pierced and also carry this dye-container, but apart from this their heads are unadorned in any way. Perhaps as they carry their heavily laden string bags slung from the centre of the forehead any form of head decoration would be in the way.

All adult men wear beards of some sort, often decorated with brightly coloured beetles or even the dried skins of small birds. Young men as yet unable to grow good beards frequently wear chin straps of Job's tears, the ends left hanging from the ears and decorated with tufts of cus-cus fur.

Necklaces are worn by men and women, commonly pigs' tusks strung together, or one or more rings of stiff cassowary quill with the feathers removed. A pendant of a single white conus-type shell is worn by most men, and occasionally by women. This is a very highly prized decoration, reputed to come from the Omtamin. Narrow bands about half an inch wide, knitted from native string, are worn by both sexes sewn tightly round the arm above the elbow and, less frequently, round the leg just above the calf. These are sometimes made with fringes about an inch long, a type favoured by the Telifomin proper and the Eliptamin. Armbands of twisted or plaited rattan are common, and many of the older men wear a twisted band made from the penis of a wild pig, but this is probably more a trophy than a decoration. A complicated basket-work disc about 8 inches in diameter, with a hole in the centre, is also worn as an armband, but this is rare and is possibly not indigenous.

Woven bands of native string, usually about an inch wide, are worn over one shoulder and under the arm on the opposite side, either singly or in pairs, one over each shoulder. They are sometimes fringed like the armbands, and attached to the fringe one often sees the cigarette holder or other small belongings of a deceased relative. One or more long strings of Job's tears may be worn in the same manner. Strands of thin rattan are wound loosely round the waist, and are usually made up into some form of ornamental knot in front.

Besides being a decoration, this rattan is used for making fire. A dry stick is split and a wedge inserted in the split, the apex of which is then placed on the ground on a small heap of tinder and the stick held down with one foot. A length of rattan is passed underneath the stick, between it and the tinder, and the ends of this rattan are then grasped in both hands and pulled quickly backward and forward until the stick begins to char and the tinder starts glowing. The latter is then taken in the hands and gently blown and fed with light, dry material until a flame appears. A thicker type of split rattan decorated with crude carving or poker-work is also worn round the waist, but this appears to be purely for ornament.

The penis-covering of these people is of a type which, so far as I know, is not found elsewhere in New Guinea. It is a hollow, tapered brown gourd obtained in many fantastic shapes. Round the base is fixed a wide plaited band of finely split rattan, to which is attached the thin woven waistband of native string used to hold the gourd in place. Youths below the age of puberty wear no covering, and circumcision is not practised.

The abbreviated grass skirts worn by all women from the very earliest age are made in two sections, each about 4 inches wide, which hang down in front and behind, leaving the thighs bare. They are tied round the waist with native string, and new ones added from time to time, without removing the old, until the resulting collection resembles a thick tussock of grass rather than a skirt.

String bags are worn by both men and women: the smallest no bigger than a finger stall, single or joined together like the fingers of a glove; the larger ones, about 8 inches long and up to 4 inches wide, are worn round the neck and hang down in front, carrying tobacco, small grasshoppers, and lizards to eat and many

other things. Larger bags about 10 inches square are worn by men only, round the neck and hanging down the back, the outer side usually being covered with a thick mat of cassowary plumes or feathers of some other bird. The work-bags of the women are much larger than the men's bags, invariably without decoration, and essentially for hard use rather than for ornament. They are used for carrying taro, sugar-cane, firewood, children, etc., and are worn slung across the forehead instead of round the neck.

The main weapon of the mountain people is the bow and arrow, the spear being unknown. The range of an arrow is not above 150 yards, and though these people are extremely rapid snap-shooters, they are not as accurate as might be expected, and in the many competitions we had seldom hit a 5-inch mark at 25 yards. The bows are about 5 feet long, made from black palm wood, and fitted with strings of split rattan or bamboo. Since the latter material is too brittle to be bent into a small loop, the end fixings in this case are made by means of a short cord of twisted fibre. No palms grow in the valley of the upper Sepik, so all the bows have to be traded in from people such as the Fairolmin or the Omtamin, who live at a lower altitude.

The arrows, usually eight, and not poisoned, are carried loose and held in the left hand, which also grasps the bow. The shafts are of wild cane-grass, and the heads conform closely to one or other of eight standard patterns. Three are of bamboo with varying forms of decoration depending on whether they are primarily designed for warfare or hunting, and three more, which are used either for war or hunting, are made of hard wood, either plain or with barbs cut out in fretwork. An interesting arrow consisting of a round or flattened tree root fitted into the shaft in place of the blade is used for snakes, small birds, etc., and also against women of an enemy tribe, either to render them unconscious with a hit on the head or to lame them with a hit on the thigh and so facilitate their capture. Flat, sword-like clubs of palm wood are used for close fighting, and a few daggers, made from the femur of a cassowary, were seen. For defence against enemy bowmen there are large shields of light wood about 5 feet by 2, with a crude handle of rattan, and the front has a carved design picked out with red, white, and black. Their use is uncertain, but probably they serve to protect a line of bowmen in single file.

The unit of social life is the village, and in the smaller villages at any rate it would seem that most of the inhabitants are related to one another. In none of the villages, where we were always welcome guests, did we find any evidence of a chief or even a ruling body of old men. Every man lives his own life, but joins in matters of common weal such as warfare or making a new garden. Karius has described the chief of Bolowip, but we believe that his position was probably due more to a strong personality than to any inherited or elective right.

The village has usually six to twelve houses in a small hollow square or rectangle, with a men's house, or *iol um*, at one end, separated from the village by a low fence about 2 feet high, along which is planted a row of sugar-cane, crotons, or some other ornamental shrub. Another house, which appears to be used only for dances, may be inside this enclosure, though it is more often close to but outside the fence. Near each village there is a solitary house

known as the *unung um* (women's house), and it is believed that women retire there when in labour.

The houses, which are raised a foot or more from the ground, are built of split sticks placed vertically and lined inside with split and flattened pandanus bark, also used to cover the floor. The standard gabled roof has a very low pitch and is covered with thatch, probably once made of sugar-cane tops, but by the repairs of years become a mass of bark, leaves, and grass. The doorway is a flat slab of wood about 3 feet wide reaching from floor to roof with a hole in the centre about 6 inches from the floor. This hole, which is about 2 feet high by 18 inches wide and elliptical, is closed when the owner is away by a barricade of sticks laid closely across the door, and held in place by uprights which are permanent fixtures. Above this opening the slab narrows to a point near the ridge pole, and the upper portion always carries a crude design, carved and painted with red, white, and black. The floor extends beyond the front wall of the house about 18 inches and forms a kind of platform on which to sit.

Above the square fireplace in the centre of each house are racks for storing wood or drying tobacco. The walls are occasionally decorated with a few trophies, pigs' or cus-cus' jaws, but apart from these the houses contain nothing except the weapons, string bags, food, etc., of their owners.

The *iol um*, besides being the sleeping place for all the adult men, is also the repository for trophies of war or of the chase which belong to the village as a whole. Arranged in neat rows round the walls are the lower jaws of wild pigs, and in the centre of the rear wall opposite the door a crocodile skull may occupy the place of honour. In a small one I counted over nine hundred pigs' jaws, and in that of the largest Telifomin village there cannot be less than four thousand. This particular house is much larger than any others in the district, and differs from them in that it is raised about 10 feet off the ground and has a smooth outside wall made from plaited palm leaves instead of the usual split timber. It would appear that in some way this is the chief *iol um* of the whole Telifomin group. Most of these houses possess a few heads reputed to be those of enemies slain in battle, but they do not appear to be nearly so highly prized as the pigs' jaws or the crocodile skulls. These heads are merely smoked over the fire and hung on the wall in the string bags of their late owners. No weapons are ever taken into these houses, and rarely are women or children allowed inside the fence surrounding them.

The dance house or *atrol um* is completely bare inside and not used to sleep in. There are usually two fireplaces. From the roof hang thin ropes of rattan ending in a large knot or loop about 5 feet from the floor. Their purpose is not certain, they are probably used to hold while dancing. The dance is a very simple movement consisting of sliding the feet backwards along the floor and then kicking up from the knee, with a few words of a song, endlessly repeated, or accompanied by a continuous *Yop*, *yop*, *yop*, and the beating of drums.

The villages are not defended in any way against a sudden raid by an enemy tribe. Gardens are made on the slopes of the numerous small ravines with rich soil and good drainage. Clearing for the garden is done by the men, who cut down the trees with stone adzes or ring-bark them with fire. The fallen timber is allowed to dry and then burnt, the ground loosened with pointed sticks, and the crop planted. Groups or families within a village join to make

a garden, of which each individual has his own section. The produce however appears to be common property, and within a village, and even between adjacent friendly villages, many things are shared. After a garden has been in use for some years it is allowed to lie fallow and a new one started, the old one being reopened later.

As many gardens are some miles from the village and close to the inter-tribal boundary, small stockades are built for refuge in an enemy raid. Sticks about 8 feet high are placed vertically close together in the ground to form a circular arrow-proof enclosure about 10 feet in diameter. A small round opening in one side makes the door, and sticks for barricading it are kept close at hand. Loopholes an inch square are cut all round the walls.

A more elaborate retreat, known as a *wassi um*, is often close to but on the enemy side of the garden, and consists of a tree-house about 30 feet above the ground. Unlike many such houses in other parts of New Guinea, a standing tree is not the main support; the house is built on piles with curved sway bracing. It is entered by a sloping ladder which forms part of the structure and has a narrow verandah facing the garden. The house has a fireplace in the centre, and is exactly like an ordinary village house except that it has no decorated door-slab. It is designed for defence, but is also used as a club-house where the men can eat and smoke and sleep while guarding their women working in the gardens below.

Food was abundant during our stay in this district, and as the seasons must vary little from year to year, we thought that the scarcity mentioned by Karius was more due to fear and unwillingness to trade than to any failure of the crops. The staple food of the mountain people is taro, sweet potato, and sugar-cane; but bananas, cucumbers, and manioc are also cultivated. Food is either baked in the ashes or eaten raw, except for taro, which is often finely grated and baked in banana leaves, spread on a large slab of bark or wood and covered with juice squeezed from the seeds of the long red mountain pandanus. A spoon made from the thigh-bone of a pig is used for scraping the taro, and for eating the mash.

Sago grows in the valley of the upper Fly and at the headwaters of the Om, but not in the higher altitudes of the Sepik valley. The seeds of the round green variety of mountain pandanus are eaten either raw or baked, and a kind of Guinea grass is plentiful, which when warmed in the fire and eaten raw tastes not unlike sweet corn.

For meat there is of course the village pig, living by dozens in and around the houses. Cassowary and wild pig are occasionally shot, and cus-cus, native cat, mice, snakes, birds, and grasshoppers all help to swell the menu. Across the shallow gutters which carry the surface drainage of these plateaus, small barricades of sticks are erected, with a narrow opening, in which a noose of native string is hung from a bent and springy stick. Snipe feeding along these rivulets should release a trigger which allows the bent stick to fly up and draw the noose tight about their necks, but we have no evidence of a bird ever having been caught in one of these snares.

Conical basket-work fish traps were seen in a few villages, but all looked long disused and we were unable to discover what fish, if any, were caught in them.

Water, carried in a gourd or hollow bamboo, is the usual drink. A fermented beverage with a sweet and sickly taste was once brought into camp by an Eliptamin, but seemed unknown to the Telifomin and other natives present.

Tobacco is cultivated and all men smoke, but the women do not. A fat conical cigarette is rolled in a leaf and smoked without a holder, or in a thin bamboo 4 to 10 inches long and about half an inch in diameter.

Of the marriage laws we knew little, except that wives are obtained by purchase, the father of the bride receiving payment of pigs, decorated string bags, bows, and cowrie shells. Polygamy is common, and though some men have as many as five wives, the average is about two. Exogamy is certainly not forbidden, several men having wives captured in battle from hostile tribes. The marriage tie is binding and any violation is punishable with death. The women, as is usual among native tribes, are employed as beasts of burden but appear to be in no way oppressed.

We know nothing of their religion, and at no time did we see any object held in especial reverence or awe, with the possible exception of the pig. The killing of a pig is an occasion of great ceremony at which neither women nor children may be present. The carcase is taken into the men's house and eaten, and we believe that only grown men participate in the feast. Whether this is entirely due to greed on the part of the men, in a land where meat is scarce, or whether it has some deeper significance, we were not able to discover. Certain it is however that anything to do with a pig after death, with the exception of the pig tusk necklaces previously mentioned, is taboo to women and children.

Every man carries a small piece of pig fat wrapped up in his string bag; it is kept most carefully concealed and may not even be mentioned except in whispers. On occasions the fat is rubbed over the face and arms, and though the purpose of this was explained to us many times, we were never able to understand the story. Both men and women paint their faces, arms, and thighs with wide red vertical stripes, but again we could not understand the voluble explanations given.

No medicine men exist, and no plants with special medicinal properties appear to be known, although healing charms of two types are carried by most men. One was a hard flat red bean, which is rubbed on the forehead to take away headache; and the other, a spherical white seed about three-quarters of an inch in diameter, the application of which to a sore or wound is supposed to be an unfailing cure.

Trading visits make a welcome diversion from the daily routine and many excursions are made to neighbouring friendly tribes. Tobacco, pigs, string bags, bows, and stone adzes are exchanged by barter: there appears to be no general standard of value, and no form of coinage is used. Women accompany the men on these visits but take no part in the transactions. An anomalous situation arises in the case of a man with a wife captured from an enemy tribe. After she has become properly "naturalized" in her new village, she is allowed to go home and visit her own people from time to time to trade with them on behalf of her husband. In this way some trade takes place even between hostile tribes.

The only native arts and crafts which exist are the string work of the women and a small amount of carving. The former is confined to useful articles such as string bags or body bands, and is of interest mainly on account of the implement used: a needle made from a small cus-cus bone which is an exact replica, even to the eye, of the needle of civilization. Carving is found on all arrows and cigarette holders, and conforms closely to standard designs of the crudest rectangular form, even the circle being unknown. The carving tool is the upper jaw of the cus-cus, the front projecting tooth of which is skilfully used to cut out a pattern in relief. Shields and the front door-slab of houses are also carved, but in these cases the pattern is less regular and less standardized. We could recognize no attempt at the pictorial representation of any common objects.

Of musical instruments there are only the drum and the jew's harp. The former is a conventional type of hand-held wooden drum with a lizard skin covering, and is tuned by means of small pieces of gum stuck on the skin. The harp is an internode of thin bamboo out of which two longitudinal strips have been cut, leaving a thin splinter of bamboo, attached to the node at one end, to act as the vibrating reed.

In conclusion, it may be said that to the anthropologist this district must indeed be an attractive one, where a primitive native culture unspoiled by civilization may still be studied. To the biologist also it offers great scope, since here collecting may be done at all horizons from 4000 feet to 10,000 feet within a few days' march. But from the economic point of view the region is unattractive, both from its geographical isolation and its lack of any rich mineral deposits. A vast amount of the more readily accessible coastal country of New Guinea still awaits development and it is hoped that the Administration will see fit to prevent the exploitation of this area and preserve it as one of the few remaining sanctuaries for the unspoiled native races in New Guinea.

Note on the work of earlier explorers

Some further notes on the work of the earlier explorers in this region are submitted, not with any idea of criticizing their results, but to correlate them with what, as a result of our recent work, we now know of the country.

The central mountains of this part of New Guinea were first seen by D'Albertis, who in 1876, from a hill near Macrossan island, ". . . saw them like giants of different heights towering one above the other and extending from the principal chain down to the river." These mountains he named Victor Emmanuel, in honour of his king, and on his map this name embraces the whole of the dividing range of New Guinea, extending from the Dutch border on the west to the Finisterre range on the east. There can be little doubt that the mountains which he actually saw are those which we now know as the Hindenburg, Williams, and Donaldson ranges, and also perhaps the Star mountains.

Fourteen years later Sir William Macgregor observed the mountains from a point slightly below the junction of the Black and Palmer, and the main range which he could see in the distance he concluded was the Victor Emmanuel. It is more than likely however that what he saw was the range now called the Dap, and to Karius must go the honour of being the first to

sight the Victor Emmanuel range as we now know it: that is, the continuation of the Hindenburg range on the northern side of the Wungop or Strickland river. It is also difficult to decide which was Sir William's Mount Donaldson, but it is probably that eastern extension of the highest of the limestone ridges south of the Williams range, which, following Austen's suggestion, I have called the Donaldson range. The highest peaks in this range are probably those named by Austen Mount Wuni and Mount Lyons.

In the report of his journey up the Tully in 1924 Austen refers to the Victor Emmanuel range as mapped by Macgregor, but it is almost certain that the mountains which he saw behind the Donaldson range were part of the Williams range, and the eastern peak for which he suggested the name D'Albertis Dome can be none other than Mount Sare. He could not, from his position, have seen the Hindenburg range lying to the north.

Karius, in the map accompanying the report of his journey in 1927, shows the Victor Emmanuel range as varying in height from 10,000 to 12,000 feet, but he had no opportunity to take aneroid readings, and I am doubtful if it

Three traverses of the upper Fly river

anywhere exceeds 10,000 feet. Further, both it and the Dap range should, I think, be shown as about 4 or 5 miles more to the south.

The Kaban range mentioned by Champion, though at first assumed to be what I have called the Williams range, is obviously that knife-edged ridge of limestone on the southern side of the Bol valley for which we obtained the native name Melokin. I do not suggest that the latter name is the more correct, as it is well known that different tribes often have different names for the same natural features. In the same way the Sakan, the tributary of the Sepik mentioned by Champion, is the river which I have called by its Telifomin name, the Ilim. It is also possible that the January river is the headwaters of the stream which enters the Sepik from the east in about lat. 4° 25′ S., and which was named by Dr. Behrmann the August.

Much has been spoken and written about the frequent changes in the course of the Fly river, and although the presence of numerous ox-bow lakes along its course proves that many such changes do indeed take place, it is doubtful if they occur as rapidly as is generally supposed. No proper survey of the river has ever been made, and the unavoidable errors of a time-and-compass traverse made from a small boat probably account for much of the variation between the maps of different explorers.

Three traverses of the upper Fly river, from D'Albertis Junction to Thompson Junction, are shown in the accompanying sketch-map. The first was made by D'Albertis in 1876, the second by Macgregor in 1890, and the third, by our expedition in 1937, was adjusted to latitudes at D'Albertis Junction and Palmer Junction. Although they vary considerably in latitude and longitude, and in small details of the river bends, it will be apparent, if we bear in mind the inherent inaccuracies of this system of mapping, that the course of the river has changed little in the course of the sixty-one years.

Note on new names

The English names used in this paper are those which have been deemed necessary for reference where the native names could not be obtained.

The Williams range I have named after J. W. Williams, the leader of the expedition, without whose courageous planning and refusal to consider failure the expedition could hardly have been carried through.

The Behrmann hills will, I hope, perpetuate the memory of the magnificent work carried out in the Sepik area by Dr. Behrmann in 1913–14.

Return Creek, January river, and Wednesday island were the names used by the party throughout the expedition, and there seems to be no reason to alter them.

DISCUSSION

Before the paper the DEPUTY PRESIDENT (Professor KENNETH MASON) said: To-night I have to introduce Mr. Stuart Campbell, late of the Royal Australian Air Force, who was first known to us as a member of Mawson's expedition to the Antarctic in 1929–30. He has an extremely interesting paper on New Guinea to read to us and I will ask him to commence at once.

Mr. Stuart Campbell then read a summary of the paper printed above, and a discussion followed.

Major O. C. W. FUHRMAN: I would like to express, on behalf of the High Commissioner for Australia, Mr. Bruce's regret that he was not able to be present this evening.

The extraordinarily interesting paper which Mr. Stuart Campbell has read has, in the main, dealt with exploratory work by air in the regions of the Fly and Sepik rivers—two great waterways which serve Papua and the Mandated Territory of New Guinea respectively, and it might perhaps be thought appropriate if I should refer very briefly to both of those territories.

It is now more than fifty years since the Protectorate of British New Guinea was proclaimed. Until 1906 the Colonial Office in London governed its affairs; then it was transferred to the control of Australia and became the Territory of Papua. It is not too much to say that the Australian record of administration in Papua ranks high among colonial administrative achievements. By dint of courage and enterprise on the part of District Officers in exploring the interior, and by a consistently intelligent study of Papuan customs and beliefs and allowing those considerations full weight in the administration of justice, the authority of the Papuan Government has created contentment and won the respect of the native people of that Territory. In the coastal areas, especially around Port Moresby, the strides made in technical education of the natives are amazing. Those natives are now increasingly becoming carpenters, plumbers, electricians, road-makers, and craftsmen in other trades. Moreover, the Papuans are not dying out as was once feared; their numbers are, I under-

stand, even increasing slightly. The credit for that achievement belongs to the Australian Government and to the sagacious and sympathetic policy adopted by the Lieutenant-Governor, Sir Hubert Murray.

The Mandated Territory of New Guinea is another problem altogether, much more difficult of administration and with perhaps a greater degree of responsibility. In the development of New Guinea, Australia is facing a task the enormity of which is not always fully appreciated. For example, it is not generally realized that this Mandated Territory consists of more than six hundred islands scattered over 1,000,000 square miles of sea. When the Civil Administration under the Mandate was established in 1921, it came into existence with almost insuperable obstacles confronting it, without a trained tropical service, without money, without forced labour, but with the recognized heavy obligations to the League of Nations. A number of years has passed in which there has been sufficient time to judge whether the Administration has carried out the duties entrusted to it; whether a reasonably efficient administrative Service has been created; whether there has been moral and material advancement of the natives; and whether, subject always to the preservation of the interests of the natives, the white population has been fairly treated. His Majesty's Government in the Commonwealth of Australia holds no uncertain opinion on the points I have mentioned. It affirms that the Administration is sound; that, although we are not without the problems associated with colonization, there is and always has been a sincere and earnest endeavour to build up a Service of which future generations will be proud and the efforts of which will be reflected in the higher level of culture to which the native population may eventually attain. The Administration's policy, if not spectacular, has had concrete results of which Australia is proud and which guarantee that the obligations arising out of the Mandate have been entirely fulfilled. Behind the mind of the Administration is the will of the Australian people to ensure the well-being of over half a million natives. The Commonwealth Government regards the exercise of its responsibilities as implying a higher rôle than the mere passive discharge of a duty and, in carrying out the terms of the Mandate, the Australian people feel that their primary considerations are the uplift of the native and the economic development of the Territory.

I should like to make a passing reference to what might be described as the essence of Mr. Stuart Campbell's paper: aerial transport, and particularly in relation to its use in New Guinea.

For the most part the mainland of New Guinea consists of chains of mountains, dense jungles, and miasmic swamps. The country is rough and broken, and is subject to intense tropical rainstorms. These factors render roads almost prohibitive in cost of production and maintenance. Something probably unique in the history of modern times is New Guinea's share in the development of air communications, and it is unlikely that the aeroplane has figured so largely in the development of any other country in the world as it has in New Guinea.

When aerial transport in the Mandated Territory was first mooted a few years ago, aviation critics were appalled. They insisted that an aeroplane transport service, under the blistering conditions of the tropics in a primitive country without even landing-grounds or workshops or ground organization of any kind, was little short of lunacy. To-day, New Guinea has some forty aerodromes and emergency landing-grounds; more than three dozen registered aircraft; and, in the last year for which I have figures, nearly twenty thousand flights were made covering approximately 1,500,000 miles. That flying is carried out over country which experienced visiting airmen describe as a "nightmare"; it is the country over which Mr. Stuart Campbell has flown. The unbroken

continuity of civil aviation in New Guinea is another sidelight on the pioneering spirit of those engaged in administering the Territory.

Before concluding, I should like to voice what I think must be in the minds of every member of this audience, namely, that this Society is to be congratulated on its initiative in arranging for Mr. Stuart Campbell to read such an interesting paper. I have very much pleasure in supporting the vote of thanks so warmly expressed by your Chairman.

Mr. GALPIN: We are much indebted to Mr. Campbell for his most interesting lecture. It has revealed one more instance in which aviation has made survey not only easier but possible. When we think of the hardships the ground party endured to cover some 40 miles, the difficulty they had in establishing their camps, and the ease with which the expedition could be carried on as soon as an aerodrome or seadrome could be provided where stores and men could be landed, we realize how many places in the world are now thrown open to scientific explorers in a way which was not possible some thirty years ago. We must, I think, agree that there are now very few portions of the globe on which in the future we shall have to write the words *terra incognita*. Not only is the actual labour of an expedition made so much easier and the expedition itself made possible, but those who have come in contact with the brilliant work which is being done all over the world by the Air Survey companies of this country and have been able to see some of the photographs that they have taken from the air showing geological strata and geological forms which are quite unobservable on the ground, can observe how valuably the scientific knowledge of the world is increased by the use of aviation.

I think Mr. Campbell has been unduly modest in his lecture because he has not blown his own trumpet about some of the difficulties which he encountered. I remember some twenty-three years ago flying back from France, and thinking I was nearing Harwich, when suddenly the cliffs of Dover loomed up in front of me. I can quite understand and sympathize with Mr. Campbell's feelings when he saw a large mass of rock formation towering over his machine and apparently capped in cloud. It is a difficult situation in which to find oneself. How much more difficult when the lives of a party of men struggling through the bush depend on one's success in dealing with such a situation. I feel sure the expedition owes a great deal more to Mr. Campbell's own skill and resource than he has let us realise during the course of his lecture.

The last speaker referred to the increase of aviation in Papua and New Guinea and one welcomes what he said as to the development of the country by this means. I understand that a line is now running from Sydney right up the east coast of Australia to Port Moresby and that there will eventually be a line some 2000 miles long subsidized by the Australian Government at a cost of something like £65,000 a year, which shows the interest which the Commonwealth of Australia is taking in the use of aviation for the development of their near-by territories.

Finally, as I am here representing to a certain extent the Air Ministry and my colleagues in that Department, I would like to say how much we appreciate the interest which the Royal Geographical Society takes in aviation and its relation to the science of the subject which the Society particularly studies. It is a great help to us to feel that a learned Society is making full use of what is really one of the most valuable instruments now to its hand.

Major HAROLD HEMMING: My interest in New Guinea has been confined to the angle seen from the office stool in London, but I have worked as a colleague with Mr. Campbell and that has been a great privilege. He is a most modest individual and I only wish that you could have shared with me the reading of

some of his reports and letters; he is always very outspoken and constructive. He alarmed us all a great deal by becoming missing for a week or ten days up the Fly river. His only grouse when he returned was that he did not mind so much his aeroplane letting in rain, but it was somewhat difficult, under the conditions in which he was working, to find that no provision had been made for the water to leave the cabin!

As previous speakers have said, the air is playing a very great part not only in the development of British New Guinea but also in Dutch New Guinea. Recently a most successful air survey has been completed of some 40,000 square miles of oil areas of Dutch territory and good results were obtained from the air survey of the Bulolo Goldfields in north-east New Guinea. Mr. Stuart Campbell was responsible for the supervision and flying of this latter operation, prior to the travels which he has described to-night.

Major Fuhrman, in referring to the splendid work carried out by the Australian Government in the north-east part of New Guinea, mentioned that a large number of aerodromes had been established there and that a considerable amount of passengers and freight was flown to the goldfields. It is important to remember however that this development work is mostly confined to the Bulolo district in the eastern part of the territory, whereas Mr. Campbell's operations were undertaken over areas in New Guinea completely devoid of landing-grounds or any form of civilization.

I would like, in conclusion, to add my thanks to Mr. Campbell for his most interesting and helpful paper.

Wing-Commander F. C. V. LAWS: I would like to endorse the remarks made by Major Hemming with regard to the modesty of Flight-Lieutenant Campbell, as I know him. He has said nothing as to the hardships of his job in New Guinea, nor did he say that when he went there he had just completed nineteen hard months of flying on Air Survey work in the goldfields of Western Australia. I can pay a high tribute to him as a pilot and organizer in the particular branch in which I am interested, namely, air survey and air photography. During the period of nineteen months that Flight-Lieutenant Campbell was with me in the west of Australia he was my right-hand man and I should like to take this opportunity to thank him publicly for his part in a very difficult undertaking.

The DEPUTY-PRESIDENT: The speakers who followed Mr. Stuart Campbell have said everything I was going to say, and there is little for me to add. I have read the lecture through and have found in it information which will repay close study. Mr. Stuart Campbell has not been able to give, in the short time allotted to him, anything like a full account of the work, but I am sure you all agree that we owe him very hearty thanks for an extremely interesting lecture.

NATURAL RESOURCES OF PALESTINE

A. BONNÉ

PALESTINE, a region whose natural resources seemed limited as compared with those of other countries, has, through pressure of circumstances, seen wide developments in the course of the past fifteen years. New methods of utilizing underground water resources have, for example, made possible a new extension of agriculture. In estimating the potentialities of the country, the progress of modern technical developments requires the abandonment of the old conception of possibilities that were "naturally preconditioned." Whereas prior to the War Palestine had been a predominantly agricultural area, conditions have considerably changed during the two post-war decades. It is true that up to the present day the primary source of living of the bulk of Arab population has been agriculture; and citrus culture—one of the spheres in which the most remarkable extension of post-war times occurred—is likewise connected with and dependent on the soil. At the same time however there is a tendency towards urban callings, particularly in connection with industry and transport. Nevertheless, for some time to come the extent of cultivable land as well as agricultural possibilities will exercise the greatest influence on the growth of population and on its economic development.

The area of the country is estimated at 27,000 sq. km., 10,000 sq. km. thereof being cultivated land. The estimates of cultivable area vary, and in view of the importance of this problem, it will be dealt with later in more detail. In spite of the small size of the country there is a remarkable difference in its natural conditions, and consequently in its agricultural zones. It may therefore be expedient to deal first with the climatic conditions and their effects.

Climate and zones of cultivation

The climate of Palestine has, generally speaking, a Mediterranean character. When examined in detail however there are found to be considerable differences between the various zones of the country, the morphological structure of which has tended to emphasize their very different methods of cultivation. The zones extend from south to north, running parallel for the most part, and they may be distinguished as follows: the coastal plain from Gaza to Acre; the mountain land of west Palestine; and the Jordan depression. Along the whole of the coast there predominates a pleasant, almost unvarying Mediterranean climate with mild winters and humidly warm summers. In the Jordan depression the summer is tropically hot, the winter mild. In the mountains the days in summer are hot, cooling off rapidly in the evening. The fluctuations in temperature between the diurnal maximum and the nocturnal minimum are here considerable. In the mountain country the winter is rough and rainy and is characterized by frequent and heavy storms. The hottest month in the year is August, and the coolest is January.

The following table shows the absolute maxima and minima for three years and the different parts of the country, and the average annual temperatures.[1]

[1] Taken from Palestine Bluebooks.

	Jerusalem		*Tel Aviv*		*Haifa*		*Beersheba*		*Jericho*		*Beisan*	
	max.	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*
1933	40	−3	37·6	3·8	37·7	3·4	46	0·3	47	2·2	45	0·6
1934	41	−0·5	36·5	4	41·7	4·6	41·7	0·2	45·6	2·5	45	0·5
1935	37·3	−1·1	45·8	6·7	43·7	7·2	44·7	—	45·8	6·7	45	3

Average annual temperatures (mean in degrees Centigrade):

	1933	1934	1935
Jerusalem	17·6	17·3	18·2
Tel Aviv	19·7	20·2	20·6
Haifa	20·7	21·7	21·8
Beersheba	19·3	19·9	—
Jericho	22·5	23·3	20·6
Beisan	21·6	22·5	22·5

As a result of the differences in temperature there is considerable fluctuation in the ripening time of the various agricultural products. Thus grain in the Jordan valley is cut about six weeks earlier than in the mountains. Again between coastal plain and mountains, as also between Jordan valley and coastal plain, there is a difference of about three weeks in the harvest periods for fruit, vegetables, and grain.

Rain is a factor of decisive importance for the whole of agriculture: apart from the immediate and direct advantage of rain for vegetation, it feeds the ground water sources. The amount of rainfall in Palestine is, generally speaking, equal in amount to that of central European countries, but there are regular periods of drought in which over a series of years rainfall is much below the average.

	Average annual rainfall		*Rainfall during recent rainy seasons* [1]		
	Number of Seasons	*mm.*	1931–32 *mm.*	1933–34 *mm.*	1934–35 *mm.*
Jerusalem ..	87	636·6	324·6	391·7	509·2
Tel Aviv ..	30	531·2	315·7	405·5	718·0
Haifa	23	619·1	494·8	589·9	548·7
Beersheba ..	14	192·8	301·2	336·3	243·5
Jericho	12	116·6	61·5	93·0	154·0
Beisan	9	274·2	156·5	211·5	377·0
Jenin	14	481·2	329·2	377·6	548·0

The rainy season is from October to April, during which period distinction must be made between the early rains in November, the main rainfall usually in January and February, and the later rains in March and April. As mentioned in the Bible, the early and later rains have special functions as regards agriculture. In the summer months the dew plays an important part. In places where it occurs in abundance, it enables the farmer to sow a summer crop without having recourse to artificial irrigation. Dew is plentiful in the coastal plain, the western mountain ranges, the plain of Jezreel and the Carmel district.

[1] Taken from Palestine Bluebooks.

Water supply and land development under existing irrigation conditions

During five to six months of the year, from May to October, there is little or no rainfall; Palestine possesses no central watercourse which could serve for irrigation; and during the rainy season the rainfall is unequally distributed over the entire country. The subsoil-water is also unequally distributed in the country. In view of the features of the Palestine climate referred to above, the amount of water available for irrigation and the methods of irrigation determine the scope of intensive cultivation.

In the coastal plain water is generally abundant. Besides several rivers which empty themselves into the sea, and the water of which has scarcely been utilized as yet, there is ground water available everywhere for irrigation purposes. This water is pumped out by motor pumps. The depth of the bores varies, occasionally amounting to several hundred metres. The installation of such wells is expensive, especially when they have to be sunk deep. Owners of small plots of land generally join and construct one common well, or else must purchase water from their neighbours. The extension of citrus cultivation has considerably furthered the technique of well-drilling, and there are different methods of sinking wells. Jews prefer the system of drill-boring, whereas Arab planters prefer digging when sinking a well. The dug well is constructed almost entirely by hand, *i.e.* by inexpensive but skilled local labourers. In the drilling of wells great progress has been made of late since drilling machinery driven by motor-power came into use, especially for deep boring. The number of drilling-machines in the country amounted in 1936 to 40, apart from 40 additional hand machines. The number of wells existing in Palestine and used for irrigation may be estimated roughly at about 2500–3000.[1]

With regard to rivers the following may be mentioned. The Jordan valley is generally well supplied with water, and the river and its tributaries are sufficient to water the surrounding tracts of land. There were proposals to raise the water by motor power, thus enabling the tracts on both sides also to be watered. At present the waters of the Jordan and Yarmuk rivers are almost untouched for irrigation; but further research regarding costs, salinity, and technical provisions is needed to ascertain the possibilities of using these water resources for agriculture. In the north of the Dead Sea large quantities of water coming from the tributaries of the Jordan, are wasted. These could be used for irrigation purposes, as far as they are not saline, and their pumping up would not be too expensive despite the very considerable height the water must be lifted.

The river in the coastal plain most abounding in water which might be utilized for irrigation is the Nahr el 'Auja (Me-Jarkon). Its flow is 8·5 metres per second, through a plain well adapted to citrus cultivation. The government has recently established a plant to use the sources of this river to supply water for Jerusalem, which has always suffered from a shortage. The distance between Jerusalem and the source of the Nahr el 'Auja is nearly 50 km. as the crow flies and the difference in altitude is about 700 metres.

The springs and rivers rising and flowing in the coastal plain are reinforced

[1] These data are based on a paper by W. Stern, "The water problem of Palestine," in 'Palnews Yearbook.' Tel Aviv, 1936.

by the waters flowing down the hill-sides, but not in all cases can they empty themselves directly into the sea, because of the dunes which bar the way. The south-westerly winds, the sea-waves, and the sand and boulders carried down by the rivers have filled up their mouths. Since the war drainage works have been carried out in the resultant swamps and marshes, and canals have been built to keep off the stagnant water. A considerable number of the watercourses themselves have been improved, and their mouths have been cleared and drained.

Water supply and agricultural possibilities

Traditional agricultural enterprise in Palestine has for centuries been satisfied with the natural aid afforded by sun and rain. So long as there was no appreciable change in the number of the population and so long as the people were content with what nature offered them, there was no attempt to exploit further possibilities, and there was a complete lack of system in the utilization of the water resources.

In view of the necessity of increasing possibilities for settlement, Jewish immigration in Palestine has been particularly preoccupied with the investigation of the water conditions. The extension of the orange cultivation, demanding a considerable amount of irrigation in the rainless months, meant an important advance in the utilization of ground water for purposes of irrigation. But this cultivation was confined for the most part to places where, on the basis of actual borings, the presence of water had either been found or could be assumed. Even if geological indications occasionally played a part in the matter, the result of such borings, in as far as they were not made in places where the presence of water had already been verified, was always very dependent on chance. This state of things has been affected considerably by the adoption of geophysical methods, introduced into Palestine in 1933, by which it is possible to determine by surface measurements the geological structure of a given area without previous borings having been made. The figures published below [1] are a promising indication of the not yet exploited water resources which may make agricultural development possible in districts not hitherto considered suitable. The new methods have been proved sound in principle; further experience is required to show how extensively they are applicable.

Summary of boring in Jezreel Valley

	1925–1933	1933–1935[2]	1935–1936[3]
Completed borings	44	26	9
Successful borings[4]	14=32%	20=77%	8=89%
Average volume of water in cub. m./hr.	3	42	59
Average depth of borings ..	42 m.	90 m.	150 m.
Expenditures per 1 cub. m./hr.	£P.124	£P.23	£P.23

[2] Twenty-three months.
[3] Seventeen months.
[4] Borings which yield more than 5 cub. m. per hour.

[1] *Cf.* "Palestine Post" of 9 December 1936, p. 9 (*The Economist*, Supplement).

Cultivable and irrigable land

Recent estimates of the cultivable area have varied between 8,044,000 metric dunams, estimated by Sir John Hope Simpson,[1] and about 12,000,000 metric dunams estimated by the Commissioner of Lands and by the experts of the Jewish Agency for Palestine on the basis of the past experience of the Jewish colonizing bodies. A very recent estimate supplied by the Government to the Royal Commission gives the cultivable and non-cultivable areas of Palestine, excluding the Beersheba sub-district and the southern desert, as 7,120,500 and 6,621,900 metric dunams respectively. The difference between these figures depends essentially on the definition of the term "cultivable area." The Government definition includes only such land as can be cultivated with the resources which are at present at the disposal of the average fellah. It is evident however that this leaves out of account the improvement of agricultural methods which has opened up in recent years many areas hitherto classified as uncultivable. But even in the most cautious Report of Sir John Hope Simpson it is stressed that the possibilities of extending the present cultivable area of land are by no means exhausted. The Report states: "there can be no doubt that systematic and methodical development over a series of years will change the whole aspect of agricultural Palestine, and admit of a largely increased population " (p. 144).

The extent of irrigable land is of special interest in view of the much higher settlement capacity of irrigated land for new settlers. On the basis of the latest researches, the extent of irrigable land in Palestine is cautiously estimated at about 2,150,000 dunams.[2] Of this about 300,000 dunams are at present planted with oranges, 50,000 dunams with other vegetation requiring irrigation, there remaining a reserve of 1,800,000 dunams. On the basis of the calculations given in the Johnson-Crosby Report and the Census of 1931, approximately 15,000–20,000 settlers can live on an unirrigated area of 1,800,000 dunams. By the introduction of a system of intensive agriculture based on irrigation the number of families supported can be increased four or five times.

Water power

Any scheme of industrialization which is to contribute towards the economic development of Palestine has to meet with one important difficulty: the poverty of the country as far as combustibles, especially coal, are concerned. Without coal the local production of electric energy would primarily have to depend on the establishment of hydro-electric plant, or on the supply of oil. There exists one important source for the generation of electric energy from water power, namely the Jordan river. In the course of one year the Jordan carries a tremendous quantity of water from the northern mountains down to the Dead Sea. The idea of exploiting the difference in the level appeared the more attractive, as the large basin of Lake Tiberias offered in itself a possibility of equalizing the summer and winter levels.

[1] 'Report on immigration, land settlement, and development' 3686. (London, 1930), p. 22.

[2] The results of these researches undertaken by the Head Office of the Jewish National Fund in 1936, are included by A. Granowsky in 'The land issue in Palestine.' Jerusalem, 1936.

A concession to exploit the water-power of the Jordan on a large scale was granted in 1926, and the Palestine Electric Corporation was established. The original plan comprised the erection of three power-houses. The first power-house, opened in 1932, is near the Jewish settlement of Gesher, on the eastern bank of the Jordan, 10 kilometres south of Lake Tiberias. The second station is projected below the exit of the Jordan from Lake Tiberias, and the third one between Lakes Hule and Tiberias. At the present moment only the first power house has been equipped, and the current is distributed to central transformers in Haifa and Tel Aviv. Two large local power stations have meanwhile been erected at Haifa and Tel Aviv and supplied by fuel, and it appears that the original scheme of further hydro-electric plants has been laid aside for the present. The electricity supplied by the Jerusalem Electric and Public Services Corporation is generated in a power station based on oil consumption.

Forests

Compared with the extensive wooded tracts of Europe the forest area in Palestine to-day is negligible. The Turkish Government gave no thought to the woodland, and in the World War what was left of the forests was largely destroyed. Except for a few wooded spots here and there in the north, the new government found nothing but stumps of trees where formerly there had been large forests. In the hill country there are extensive stretches free of any woody growth. As in other border lands of the Mediterranean *macchia* and *garigue* formations cover the karst landscape and represent the principal natural forest wealth existing to-day. A special feature is the forest vegetation along the Jordan river which shows a number of tropical species. Despite heavy destruction during the war, large areas of olive groves have survived. In the plains extensive plantations of recent growth are due mainly to the efforts of the government and new settlers. According to an official description, four main types of forest may be distinguished.[1] Hill forests, of natural origin, are mainly confined to the central plateau and the northern half of Palestine. The Jordan valley forests consist of a belt of tropical trees, riverain in type, which extends on either bank of the river between Lake Tiberias and the Dead Sea. Olive groves are common in the hill regions wherever the cultivator has been able by terracing to find sufficient soil to support the spreading root system of this species. Forest plantations of artificial character date back some fifty years, when Jewish settlers introduced the eucalyptus. Many plantations were made, principally of the *Eucalyptus rostrata*, mainly in the coastal zone. With the establishment of new colonies additional plantations have been formed inland and include of late years pine varieties, mostly planted in the hill country.

In view of the importance of forests for Palestine, because of their functions in arresting soil erosion, as a storage reservoir for the exiguous rainfall, and as an ameliorator of climatic extremes, the value of systematic afforestation policy cannot be over-emphasized. It is practically impossible to recapture the abundant rain-water on the hill-tops once it falls to earth, because in the absence of forest earth it percolates through to the lower strata of rock and is lost. Therefore it is believed that the final solution of the water problem—*i.e.*

[1] According to 'The handbook of Palestine and Trans-Jordan,' edited by Luke and Keith-Roach, 1930, pp. 265, *et seq.*

conservation of rainfall—can only be achieved by systematic afforestation, upon which Government and Jewish institutions have begun work in recent years.

Mineral resources

Palestine is not by nature well endowed with mineral wealth of high value. Chalk stone and basalt, it is true, are to be found in inexhaustible quantities supplying stone for building purposes. Copper and manganese occur in southern Palestine, but their economic value is doubtful. As against this Palestine possesses in the waters of the Dead Sea a supply of potassic bromine and magnesium salts which for all practical purposes can be considered inexhaustible, and whose economic exploitation is now in progress. Blake tabulates the mineral deposits of Palestine in the following four categories [1]: soluble minerals of the Dead Sea (common salt, natrium chloride, potassium chloride, chloride of magnesia, and magnesium bromide); petroleum and earth gasses, asphalt and bituminous limestone; metallic minerals; and non-metallic minerals.

The significance of the mineral properties of the Dead Sea has been well known for a long time, but their extraction was commenced only with the occupation of Palestine by the English. The works, which began to function on 1 January 1930, employ at the moment over 1000 men, of which nearly half are Arabs.

The extraction of the salt is accomplished in great earth-pans, which have been established on the north and south shores of the Dead Sea. The salt-yielding water of the Dead Sea is pumped by means of high-power machinery through a big pipe-line into the earth-pans, and the water is evaporated by the sun until only salt remains. The chief products are potassium and bromine, the latter being principally exported to England. The extraction and evaporation is so highly favoured by the climate that the manufacturing cost is extraordinarily low. For extension purposes and for reducing the cost of production, new works have been built at the south of the Dead Sea where the technical conditions for the manufacture are more favourable than in the north. The works in the south, extending over an area of 62 square kilometres, are three times the size of those on the north bank. The production of refined potassium salt amounts at present to 50,000 tons per annum, *i.e.* a trifling percentage of world production and consumption.

Bromine is an important by-product of potash manufacture. The bromine content of the Dead Sea water, being from 0·45 per cent. to 0·85 per cent. on the surface and up to 1·2 per cent. in the depths from which the water is pumped, is much higher than in the waters of Stassfurt or in the United States, and the waters of the Dead Sea form one of the richest sources for bromine salts. Fair quantities of this product (over 500 tons in 1937) have been extracted, covering 75 per cent. of the English demand. The prospects for the profitable production of bromine, used extensively in the dye factories and elsewhere, have risen appreciably during recent years. The chief manufacturing countries are at present Germany, France, and the United States, upon which until recently the British market was dependent, Palestine occupying third place among the producing countries.

[1] G. S. Blake, 'The mineral resources of Palestine and Trans-Jordan.' Jerusalem, 1930.

The geological structure of Palestine suggests that in many places petroleum and its allied products can be found in economically remunerative quantities. In the survey of an American oil expert it was emphasized that out of the 12,700 square miles embracing Palestine, 300 square miles show geological conditions which point to the appearance of oil. That means an extraordinarily high percentage of oil-bearing surface in comparison with the size of the land, and of eight oil districts four have good prospects. Even before the war boring concessions were given at Kurnub, some 30 kilometres west and the south of the Dead Sea. There are well-founded suppositions that, as a result of the discovery of oil west of the Dead Sea, new sources of potassium will come to light.

Traces of manganese ores and of copper and chromium are to be found in the south in the neighbourhood of 'Aqaba, but work did not proceed beyond prospecting.

Of considerably greater significance are the quantities of limestone formations. The value of limestone is certainly low in comparison with its quantity, but its use, especially for building purposes, is far reaching. Through improvement in the methods of working, limestone in Palestine may in the future come into greater use as building material, although its use has declined of recent years. Basalt, which is to be found in large quantities in the north of the country, is used there extensively for building purposes. It may, in this connection, be worth while mentioning that the production of building stone provides a living for a considerable number of workers in this country, as building activities are among the outstanding branches of Palestine economic life.

Among the minerals to be found in Palestine, which are worth being mentioned are asphalt and bituminous limestone. Asphalt has been obtained in Palestine since the early ages. Small quantities of pure asphalt in the form of a conglomerate are found in Wadi el Mojib, 'Ein Jidi, and Masada. Besides, one finds pure asphalt along practically the whole coast of the Dead Sea. There are large deposits of bituminous limestone at En Nabi Musa, Safad and Tarshiha in north Palestine and at the Yarmuk. One hundred thousand tons of bituminous limestone can, according to Blake, produce 40,000 tons of lime and 8500 tons of raw oil.

Rock salt is mined in quarries at Jebel Usdum (the Rocks of Sodom) and is brought to the Jerusalem market. Important quantities of salt are further obtained by evaporation of sea-water on the coast south of Haifa. Gypsum is found in large quantities in the whole of Palestine and especially near Menahamiya where it is being exploited by Jewish colonists. Sulphur is practically as widely spread as gypsum, and is found in large quantities in Gaza, in quartz-like sandstone.

Calcium phosphates are found abundantly in the Desert of Judea and in Trans-Jordan. Most of these deposits in western Palestine are of lower quality and seldom contain more than 40 per cent. of tricalcium phosphate. Production would only be for the domestic market, in view of the low cost of high grade phosphates from Tunis and Morocco. For a definite confirmation of the possibilities of realization of this and other mineral products of the country a thorough geological examination is required.

REVIEWS

EUROPE

MODERN ENGLAND, as seen by an Englishwoman. By CICELY HAMILTON. *London: J. M. Dent & Sons*, 1938. $7\frac{1}{2} \times 5$ *inches;* xvi + 224 *pages; illustrations.* 7*s* 6*d*

The author, having dealt with a number of European countries, has now recorded some of her reflections and observations upon the present state of her own country. Though this volume perhaps lacks the unity of her earlier works, it sets out lucidly the main social and economic changes which the twentieth century has produced in England. Almost inevitably in a book of this character there is an undertone of regret at the passing of the old order. Miss Hamilton is ready to praise modern achievements when they show themselves worthy, notably the good building in Liverpool, but in general her mood is one of criticism, which is the more valuable from her moderation of expression. In her protest against mass regimentation of outlook, at least, she will carry most of her readers with her. Her book affords an hour or two of pleasant entertainment for the reader in checking her observations against his own. G. R. C.

WORTHING: a survey of times past and present. By local writers. Edited by F. W. H. MIGEOD. *Brighton and Worthing: The Southern Publishing Co.*, 1938. $7\frac{1}{2} \times 5$ *inches;* viii + 296 *pages; map.* 3*s* 6*d*

Worthing has been little written about, though a few years ago Miss Marian Frost, of the Worthing Library and Museum, made a first essay. The immediate occasion of the present comprehensive survey was a congress of the South-Eastern Union of Scientific Societies held in the town in June, 1938. Local experts have contributed the chapters, and the whole, well edited, will be of permanent interest to both residents and visitors to a prosperous town which has developed rapidly in recent years. The Worthing area now contains 8143 acres, and the present population is 63,000. An increase to a possible 100,000, with a development policy covering the next fifty years, is contemplated. Not primarily a holiday resort, the town aims at being a pleasant place of residence and retirement. In these pages pre-history is adequately dealt with by E. Cecil Curwen, Roman and Saxon times by A. E. Wilson, and local history as revealed in Domesday Book by the editor. The story is taken up by accounts of Tarring, ancient churches, and old buildings. There follow sections devoted to natural history, regional survey, agriculture in West Sussex, the glass-house industry, and open spaces. In part IV we have an account of municipal administration, while part V describes the engineering services of the borough, and the book concludes with transport, religion, education, and recreations. It is a model of what a town history should be, and the editor is to be congratulated on his selection of competent contributors and the resulting soundness of the various chapters.

What of Worthing and West Sussex in the future? In the chapter on regional survey we read that "the finest agricultural soil that exists in these islands is rapidly being built over to form a gigantic health resort." Mr. William Lawson describes how in West Sussex, "over a period of years the average loss of land to agriculture has been about 1500 acres a year, and between 1935 and 1936 the loss was over 3000 acres. Much of the loss has taken place on the most fertile soil." It will be another matter for regret if building expands up the slopes of the Downs: neighbouring Brighton should be a warning. The west-to-east conurbation of the coastal plain is now inevitable, but the Downs

should be observed as a barrier. The difficulties of drainage of the low-lying areas are frankly described, but the writer on the foreshore says no word about the very real inconvenience of seaweed accumulating on the beach. S. E. W.

FINLAND IN SUMMER. By F. J. NORTH. *Cambridge: W. Heffer & Sons*, [1938]. 9×5½ *inches;* xvi+234 *pages; illustrations and sketch-maps.* 10s 6d

There could hardly be a more admirable introduction to Finland and the Finns than Dr. North's book. As the title suggests, it is in outline the description of a summer holiday spent in leisurely travel from Helsinki to Kolttaköngäs on the shores of the Arctic Ocean, but in content it is much more than this. For Dr. North travel is not merely one method of passing the time; it is a vital and enriching experience, and one for which he is prepared by a fund of knowledge which enables him to appreciate the significance of what he sees and hears. Particularly of what he sees, for the one flaw in Dr. North's equipment is that he is unable to speak Finnish, and is therefore debarred from conversing with those who know no other language.

Of this flaw Dr. North is himself fully aware, and one of the charms of his book is that he never pretends to more knowledge or experience than he actually has. He tells what the country looks like and something of its physical history too. He tells how the people live and work, how they have adapted themselves to their surroundings, of the struggles they have had, and of how their life and environment have found expression in literature and art. His description of places is no mere string of sights to be seen or views to be admired; he makes us feel that distance is dissolved, and that we too are standing in the market-place, by the lake, or in the forest.

Dr. North does not omit to answer the questions every one asks when they prepare to visit a new country: how to get about, where to stay, what to eat, how to make oneself understood and what the people are like. The book is illustrated by a number of interesting photographs which are admirably co-ordinated with the text. M. S.

BEVÖLKERUNG UND LEBENSRAUM ESTLANDS: ein anthropoökologischer Beitrag zur Kunde Baltoskandias. By EDGAR KANT. *Tartu: Akadeemiline Kooperatiiv*, 1935. 9½×6½ *inches;* viii+280 *pages; illustrations and maps*

This work is concerned with the relationship between the population and the habitable land-spaces of Estonia, although many sides of the national life are touched on and some account is given of historical development.

Of the various names that have been proposed for the grouping of the northern countries of Europe the writer prefers that of Baltoskandia, given by Sven De Geer, as designating the peninsular units only, Estonia being reckoned as one. In the general description of Estonia's natural geographical features certain striking characteristics emerge. The country, lying at the periphery of the great Scandinavian upheaval area within the erosion and accumulation territory of the great ice-sheet, was in part submerged by the post-glacial waters released by the melting ice and in part remained above them. Considering along with these facts the somewhat unusual character of the climate, we are in a position to appreciate not only the possibilities of development in the country as a whole, but its marked differentiation into the sub-central highland region of Upper Estonia and the more level stretches of Lower Estonia, including the western and north-eastern areas, the coasts, and islands.

The author then traces the stages of human occupation during the various climatic periods of the post-glacial epoch, and shows that, whereas in late

Neolithic times human life was concentrated on the banks of rivers and on the coast yet, as early as the Iron Age, a definite shifting began, and the population in Roman times was already drifting towards the upland regions, a tendency which continued unchanged until the nineteenth century. The introduction of machinery, with improved facilities of intercommunication, gradually produced and is still producing great changes in the distribution of the population. The writer examines these changes with a view to ascertaining the causes of a general condition of instability and the direction in which they will ultimately lead.

Climatically Estonia is situated near a border-line between somewhat vaguely defined centres of contrasting oceanic and continental conditions, and a swing-over in either direction, however slight, must have vital consequences. Apart from this, in a mainly agricultural country it is natural that the population should be densest in the more fertile parts; there are however certain anomalies in its distribution that are difficult to explain. One would suppose that in the supra-aquatic regions of Upper Estonia, *i.e.* towards the centre and south-west, the soil being composed of piled-up morainic material, and therefore richer, the population would be densest and most widely distributed; it is here however that the attraction of the towns is greatest. Thus there is a tendency, prevalent in Upper rather than in Lower Estonia, to leave the countryside and crowd into the towns,

The third part of the work deals more particularly with the larger centres of population. The status, past history, and present circumstances of the chief towns are reviewed, and we find that in them the industries are mainly centred. Some show marked changes since the establishment of independence, and the reasons for growth, stagnation, or decline are given. In general the towns that have remained static are situated in Lower Estonia; border towns, whose sphere of influence no longer lies entirely within the state boundaries, have actually decreased in size, whereas the towns of Upper Estonia show a marked increase. Tallinn itself, although in Lower Estonia, stands outside these considerations and shows a marked increase owing to its position as the capital and chief port. Its sphere of influence also has widened, having even encroached on that of Tartu, the only other really large town and one possessing an important University. This comes out clearly on map xi, which also shows how some of the smaller towns tend to arrange themselves along radii of a circle with the large town as a centre.

The plates give a good idea of the strongly contrasted types of land-units that make up the whole: the tundra-like "Alvarmark" of the north-west and islands, the softly undulating wooded heights of the "bücklige Welt" in the north-west and west, and between them the variegated strips of the more intensively cultivated agricultural regions.

The bibliography covers a wide field and is very complete, while the maps make a most useful adjunct to the text. The one thing lacking is a list of the numerous tables (46) and figures (60) occurring in the text. The book throughout shows a careful investigation and handling of facts and an extreme thoroughness that should appeal to students and research workers, although the quantity of statistics may render it somewhat difficult for the ordinary reader. E. G. W.

LAND OF ICE AND FIRE. By HANS WILHELMSSON AHLMANN. *London: Kegan Paul, Trench, Trubner & Co.*, 1938. 9×5½ *inches;* xii+272 *pages; illustrations and map.* 12*s* 6*d*

All who have followed Professor Ahlmann's work on glaciers will be grateful for this popular account of the Swedish–Icelandic Expedition which he led

jointly with Jón Eythórsson in the summer of 1936 to Vatnajökull, the largest ice-cap in Iceland.

The first part of the book describes a sledge journey on to the eastern part of the ice-cap. The heavy precipitation and ablation on Vatnajökull make it an especially suitable region in which to study the growth and wastage of glaciers, but it is a difficult area in which to travel and Professor Ahlmann's account in no way diminishes its reputation in this respect. By going early in the season the party avoided the time when melting is at its worst, but instead they had to encounter a much higher precipitation and very deep soft snow. It is interesting that the author gives it as his considered opinion that the conditions on Vatnajökull present far greater difficulties to the traveller than anywhere he has been in Spitsbergen or North East Land. The thoroughly uncongenial climate, especially the phenomenal snowfall, was overcome with suitable equipment which enabled the party to carry out its scientific programme.

The second half of the book is concerned with a journey on horseback along the coast south of the ice-cap. Iceland's present-day roads deserve respect. At the beginning of this century there were only about 300 miles of road wide enough for carts. The country now has a network of roads of which some 2000 miles are open to traffic in summer and about 600 miles in winter. It is now possible to drive almost right round the coast, only the fjord region to the east and the parts south of Vatnajökull in Skaftafellsýsla being still closed. The difficulties which would be encountered in building a road through this district suggest that ponies will long remain the best means of transport. The book contains some good descriptions of this maze of streams and rivers, for ever changing their courses so that where one day there may be a river, the next there is dry land. The reader gains a vivid impression of the destruction caused by the historic eruptions of Öraefajökull and Grímsvötn-Svíagígur.

As a result of its isolation, Skaftafellsýsla probably still preserves at the present day more of the old Iceland than any other part of the island. Professor Ahlmann has much to say of the delightful people of this region, and he conveys something of the pleasure of riding mile after mile through wonderful and desolate scenery with a large and congenial company.

In an appendix is given a popular account of some of the results of the expedition in relation to glaciers in other parts of the world. There are several good illustrations and a map which serves its purpose. B. B. R.

ASIA

ALONE THROUGH THE FORBIDDEN LAND: journeys in disguise through Soviet Central Asia. By GUSTAV KRIST. Translated by E. O. LORIMER. *London: Faber and Faber*, 1938. 9×5½ *inches; 272 pages; illustrations and route-maps.* 12*s* 6*d*

Mr. Krist has written an interesting account of a journey he made in 1924. He entered Russian Turkistan by stealth in order to revisit places with which he had become familiar as an Austrian prisoner of war. Fortunately for him, several of those prisoners had remained to live in Trans-Caspia, and from one of his compatriots Mr. Krist was able to borrow a set of identification papers. Thus adequately accredited Mr. Krist was able to pass the scrutiny of several local Soviets and obtain from them the facilities he needed to travel widely throughout the country. He started out northwards from Merv towards Khiva, but the season was a severe one even for those parts, and he was forced to return to the railway by boat up the Oxus. At Samarkand he was arrested in his true identity but managed by hard swearing to have it disproved.

Travelling onwards towards Tajikistan as a Government geologist, Krist found himself in the Pamirs during the invasion of that remote mountain by the principles of collectivism. The apostles of the creed came fully armed and prepared to enforce their ideas by military measures. Krist maintains that he himself saw the Khirgiz nomads driven in flight out of one end of a valley while watching the Red Army arrive a few minutes later from the other end. Following the nomads he was caught with them by the autumn snowfalls, which, while halting the pursuit, prevented Krist's return. The Khirgiz treated him with the greatest hospitality and when they parted in the spring, the Khirgiz to the then comparative freedom of Chinese Turkistan and he back to Russian Turkistan, it was with lamentations on both sides. At length Krist made his way once more to the railway. He found that as a result of the means by which the collective principles were being enforced in the plain, as in the Pamirs, the nomads were beginning to prefer migration. The frontier was closely guarded and former smugglers were able to do a great trade in human cargo. Unluckily, Krist and the smuggler whom he chose as a guide were discovered by a frontier guard, but Krist escaped and was thus able to resume the services of his former employer, a Persian carpet merchant.

The trouble about the book is that Krist recalls events which were in fact spread over several years in many parts of the country as though he had been present at them all during a journey taking less than a year. Unfortunately this tendency can also be discerned in the illustrations: several of the captions are manifestly ridiculous. It is the more unfortunate that Mr. Krist should thus confuse personal narrative with hearsay, for clearly he was both familiar with the country and a keen observer. It is said that Mrs. Lorimer also intends to translate an earlier book of Krist's giving an account of his experiences as a prisoner of war. If so, the second book will perhaps help the reader to distinguish what is of value in the first. Regrettably Krist is no longer alive to elucidate the problems he has himself set. B. G.

[TRANSACTIONS OF THE GLACIAL EXPEDITIONS.] Vol. V. Caucasus: the glacier regions. 488 *pages*. Vol. VI. Altai, Khantengri, source of the Zeravshan. 192 *pages*. *Leningrad: U.S.S.R. Committee of the Second International Polar Year at the Central Administration of the Hydro-Meteorological Service*, 1936. 9×6 *inches; illustrations and maps*. 15 *and* 7 *roubles*. 2 *roubles each for binding*

Vol. V of the "Transactions of the Glacial Expeditions" reports the investigations carried out in various glacier regions of the Caucasus in connection with the Second International Polar Year, *i.e.* in 1932 and 1933. Owing however to the considerable number of glaciers investigated, the present volume comprises one part only of the materials collected, whilst additional papers are being published in the series "Exploration of the glaciers of the U.S.S.R." issued by the same State Hydrological Institute by which the expedition had been organized.

Actually the investigations were carried out by four separate parties working in the Elbrus area, in Svanetia, in Digoria, and in Daghistan. Their organization and methods of work are described by the leader of the expedition, E. A. Popov, in the first article of the volume. All the following articles—fourteen in all—indicate the results achieved by each of the research parties. An article by O. M. Znamenskaya and two by V. V. Piotrovich deal with glaciation, with melting and formation of micro-relief, and with run-off and thawing of glaciers in the Bogos range in Daghistan. S. R. Samoilovich, O. V. Vaneyeva, and N. M. Sokolnikov describe the glaciers of Digoria, and discuss in particular

hydro-meteorological investigations made in this area, as well as some data referring to the amount of water supply of the glacier streams of Digoria. The glaciers in the region of Mount Elbrus are described by E. I. Oreshnikova. The meteorological and other observations, as well as some experiments on evaporation and condensation carried out on the Bashkara glacier (belonging to the region) form the contents of four articles; another two articles are devoted to Svanetia and contain a description of the glaciers and of some of the characteristics of the glacier streams. They are preceded by a general analysis of the fluvio-glacial streams.

Strangely enough, English summaries are provided for all except one of the articles.

Vol. VI of the "Transactions of the Glacial Expeditions," being the last of the series, consists of various minor reports connected with the Second International Polar Year. In fact two of them must be considered, or at least appear to some extent to be, merely supplements to vols. II and III, which were devoted to Tien Shan and Zeravshan, for although the investigations described in the present volume have certainly been carried out independently, they are nevertheless concerned with the same regions as these latter extensive reports (*cf. Geogr. J.* 90 (1937) 563).

Each of the two additional reports consists of one article only. M. A. Demchenko gives a brief account of the complex scientific expedition to central Tien Shan, and to the Khantengri massif in particular, which had been sent in 1933 by the Ukrainian State Institute of Geographical and Cartographical Research, with its Director, Professor I. I. Lando, as leader. On the other hand, V. P. Uchaikin presents a provisional report on the expedition organized in 1932 by the Hydro-Meteorological Committee of Uzbekistan and led by the author to the head waters of the Zeravshan.

Whilst these two articles make up the second half of the book, the first half is devoted to the Altai expedition of the year 1933. K. G. Tyumentsev, who acted as leader, has contributed a general outline of the expedition's activities as well as a report on the geological part of the glaciological work. The report concerning the geographical part is made by B. V. Tronov. Two articles describe the Multa and Alaskuir glaciers and the ascent of Mount Belukha. The geo-botanical investigations are reported by V. D. Nashchokin. An abstract of meteorological observations is also published.

In contrast to all previous issues of the series, the present volume contains no English summaries whatever. But, as in some of the earlier ones, the reports are again accompanied by numerous striking views, and it is a pity that the photographs are reproduced so inadequately. L. L.

AFRICA

THE BIRDS OF KENYA COLONY AND THE UGANDA PROTECTORATE. By Sir FREDERICK JOHN JACKSON. Completed and edited by W. L. SCLATER. *London: Gurney and Jackson*, 1938. Three volumes. 10½×7 *inches;* lii+542, viii+545–1134, viii+1137–1592 *pages; illustrations and map.* £4 10*s*

The appearance of the late Sir Frederick Jackson's long awaited work on the birds of Kenya and Uganda is an important event in the ornithological history of East Africa. The three volumes just issued, well printed and illustrated, form a fitting memorial to one who spent more than thirty years in East Africa, serving first as Lieutenant-Governor in Kenya and then as Governor of Uganda. Throughout those arduous years Sir Frederick devoted his spare time to the

study of natural history, and particularly to birds. That he was a painstaking and accurate field naturalist is evident from a perusal of the field-notes which form the backbone of the volumes under review, and which represent Sir Frederick's share in the volumes which have been issued under his name. The rest, including the chapters on the geography of Kenya and Uganda, the origin and distribution of the Avifauna, the most useful sixteen-page gazetteer of localities cited in the text, the history and bibliography of the birds, a long list of literature referred to, keys to the orders, families, genera and species, with diagnoses of families and genera, technical descriptions of nearly all the birds and the distribution of the species described, together with the editing of the volumes, is the work of Mr. W. L. Sclater, a fact that has not been made sufficiently clear in either the foreword or the introduction.

The twenty-four coloured plates, from the brush of Mr. George Lodge, are good, but perhaps those of the birds of prey are the most striking, though some of the passerine species are beautifully portrayed. Many of the text figures by Mr. H. Grönvold, some borrowed from Stark and Sclater's 'Fauna of South Africa,' others drawn specially for this work, are of high merit.

The chapter on the geography of Kenya and Uganda is very brief and could have been extended with advantage. In it the author divides the country into four regions: the coastal belt, the Nyika, central highlands, and Uganda. These divisions to a large extent correspond with the distribution of bird life. The map which is included in vol. III is one of the sheets of the general map of Africa on the scale 1 : 200,000, about 32 miles to an inch, and was specially reprinted by the War Office. It is in every way suited to accompany the work.

D. A. B.

THE HUMAN GEOGRAPHY OF SWAZILAND. By DOROTHY M. DOVETON. (The Institute of British Geographers. Publication No. 8, together with No. 7 "Transactions," pp. v–ix.) *London: George Philip & Son*, 1937. 10×7 *inches;* xi–xvi+110 *pages; illustrations and maps.* 10*s* 6*d*

The author is able to convince us that Swaziland offers an admirable field for a treatise on human geography, and she has been laborious in amassing all the materials which she considers are essential for her monograph. The range of data here included is very wide, and it would have been an advantage to have been a little less comprehensive in the collection of materials and a little more attentive to the interpretation of those geographical influences that have a close bearing on the phases of human life in the country. As Swaziland is a political expression rather than a natural unit, it is particularly important that its place within the geographical framework of South Africa should be emphasized, lest its relations with the remainder of the sub-continent be neglected. A valuable addition to the essay would be a study of the distribution of population density, and Miss Doveton will, no doubt, turn her attention to this aspect in her subsequent work.

W. F.

DEATH BY MOONLIGHT: an account of a Darfur journey. By ROBERT D. Q. HENRIQUES. *London: Collins*, 1938. $8\frac{1}{2}\times5\frac{1}{2}$ *inches;* 352 *pages; illustrations.* 15*s*

The author's personal experiences, often very exciting ones, and his own reactions to big game hunting occupy a fairly prominent position. Both are interesting, and they never obtrude unduly, for Mr. Henriques has an active mind, and very keen powers of observation as well. One feels, moreover, that the book is a by-product of the journey, rather than its main object, and unless a journey be made with a scientific purpose, to publish concrete results, this is the impression that

all travel books should give. The main theme is game, but the descriptions of the surroundings and the accounts of the customs of the people that are interpolated, and the excursions into the history of a not generally familiar portion of the British administered world, are of more permanent interest, as are three appendices on "Desert game," "Female circumcision," and "Male circumcision amongst the Furs." D. T. R.

THE GOLD MISSUS: a woman prospector in Sierra Leone. By KATHARINE FOWLER-LUNN. *London: George Allen and Unwin*, 1938. 9×5½ *inches*; 304 (*inc.*. viii) *pages; illustrations and route-maps*. 12*s* 6*d*

Mrs. Fowler-Lunn is the American wife of an English geologist. When her husband was appointed to the Gold Coast on Colonial Government work, and was not permitted to have his wife with him, she decided to take a job with an American mining company prospecting in Sierra Leone, being herself also a geologist: they could at least travel out part of the way together and they would not be more than 1000 miles apart. So she prospected for gold, iron, chromium, and molybdenum in Sierra Leone; and this book is a narrative of her reactions to the country, climate, and native life.

She has produced a pleasing account of her life in the bush. It is not overcoloured, but is written to show her friends that the way people live in Sierra Leone differs from that in Boston, Mass. As all dates are expunged and most of the names of the persons met with are fictitious, the whole episode floats in the air and cannot be joined on to any fixed point of outside life. She seems however to have been able to look after herself, and the simple natives apparently were not usually successful in thwarting her, even if some snakes were.

Since the discovery ten years ago of mineral wealth Sierra Leone has been brought out into the world; and the author of this book is one of the pioneers of the process. F. W. H. M.

CENTRAL AND SOUTH AMERICA

BOUNDARIES, POSSESSIONS AND CONFLICTS IN SOUTH America. By GORDON IRELAND. *Cambridge, Mass.: Harvard University Press* (*London: Oxford University Press*), 1938. 10½×7½ *inches*; x+346 *pages; illustrations and maps*. 20*s*

Professor Ireland has performed a task whose scope and arduous nature is sufficiently indicated by the title; his precise care results in a volume of the highest interest to all students of South American affairs. During the century since Independence there have been constant quarrels, frequently leading to physical conflict, between the ten republics of the sub-continent, with lesser disputes concerning the Guianas and certain of the islands adjacent to South America. Almost all these disputes have arisen as a result of the heritage of haziness regarding boundaries between the former Spanish colonies; and disastrous wars, sometimes accompanied by prolonged bitterness of feeling, have paralysed the relations between sister nations whose aims and policies might be as similar as their blood.

Professor Ireland records the tangled story of thirty-two such disputes, but, happily, is able to show an even longer list of treaties that have settled, or are by way of adjusting, boundary questions. Not Spanish America alone is concerned. Portuguese America, in the vast shape of Brazil, touches too many Spanish American republics to have been able to avoid contention during the last hundred years. This part of frontier-trouble history is however ameliorated by records of compromise and common sense adjustments.

When the author deals with the most recent, and perhaps therefore most inflamed, quarrels (*i.e.* Tacna-Arica and the Chaco Boreal disputes) his aloof presentation of facts demonstrates a careful attempt at strict impartiality; it is rarely that one can make the criticism that facts might have been added to, or differently arranged.

The appendices, dealing with the original grants from 1501 onwards, with the *uti possidetis*, and with marine boundaries, are all that can be desired.

The index is adequate, and the volume is thoroughly documented and excellently produced. L. E. J.

THE OTHER SIDE OF THE MOUNTAIN: an escape to the Amazon. By James Ramsey Ullman. *London: Victor Gollancz*, 1938. 9×5½ *inches; 382 pages; illustrations and route-map.* 12*s* 6*d*

Mr. Ullman's story is given in a straightforward manner, with no attempts at fine writing and no claims of constant or indeed any peril of violent death; and with clear dates and itinerary. The journey occupied three months; it was not one of discovery, but unusual enough to be of interest.

The author went from New York to Lima, visited Peruvian coast ruins, Chosica and Cerro de Pasco; decided to cross the continent by way of the Amazon, and, with a companion, followed the Pichis trail from Tarma, down the Chanchamayo valley, and through jungle to Puerto Yessup on the river Pichis, 100 miles north-east of Tarma. The Pichis runs into the Pachitea, and the latter into the Ucayali; 1000 miles from this junction the Ucayali joins the main flood of the Amazon at Iquitos; another 2000 miles due east brought the author to Pará and a home-bound steamer.

From Tarma to Puerto Yessup the travellers journeyed for a week by car, mule-back and on foot, sleeping in primitive tambos, eating poor food, and suffering from insects; thence, canoe to the river-port of Bermudez; launches from that point took them to Masisea, Pucalpa, and Iquitos; and a larger steamer to Manáos and Pará.

Mr. Ullman's observation is acute, his aptitude for acquiring information, despite small acquaintance with Spanish and Portuguese, that of a born traveller. It is when he strays from the thing actually seen that he is sometimes in error, as, for instance, on pp. 128–9, when remarking on cities and railways; he might note that actually only the modern large cities of South America are placed on the coast, and that all the great centres of pre-Spanish foundation are far from, and high above, the littoral. As to railways, he has forgotten the Antofagasta and Bolivia line; and the two transcontinental systems of Guatemala and Costa Rica. His accuracy of observation fails when speaking of the dome on Manáos theatre; its tiles show the Brazilian national colours, blue, green, and yellow, and not "every colour in the spectrum, with a few others thrown in for good measure"; and a glance at any pocket dictionary would have told him to write "derrumbe" and not "dirumbi," among a number of casual mis-spellings.

Mr. Ullman's style is easy, agreeable, and not without wit. Illustrations are not of the first quality. L. E. J.

AUSTRALASIA AND PACIFIC

MANGAREVA: l'histoire ancienne d'un peuple polynésien. By P[ère] Honoré Laval. *Braine-le-Comte (Belgique): Maison des Pères des Sacrés-Coeurs—Paris: Paul Geuthner*, 1938. 10×6½ *inches;* xxiv+378 *pages; illustrations and maps.* 100*fr.*

Père Honoré Laval worked as a missionary in Mangareva, a small cluster of islands in the south-east of the Paumotu archipelago, from 1834 to 1871. His

record of the pre-European native culture is published here. More than half of the book is occupied with the legendary history of the people; the remainder is devoted to an ethnographic account in the usual rambling style of the period. Though in no sense a systematic description of the culture, this section contains useful sidelights on such diverse subjects as native diet, land tenure, and religious ceremonies, including an account of the initiation of priests, an important institution in east-central Polynesia as in its southern colony, New Zealand. The importance of this is its correlation with the highly developed mythological lore of these areas, which has been wrongly taken as the theological norm for Polynesia as a whole.

Laval's description of Mangarevan religion is remarkably free from moral fulminations, but in his judgments on native character and behaviour we detect from time to time traces of the "esprit dominateur, caractère emporté, isolé du monde et entraîné par des idées religieuses exagérées" which produced such baneful results that Père Laval was forced by the official investigation in which he was thus described (p. x) to leave Mangareva in 1871. From such an observer we would hardly expect impartiality on the spiritual life and moral virtues of the people.

A prefatory editorial note to an Appendix on the origin of the Mangarevans emphasizes the fact that Laval's views on the peopling of Polynesia are really remarkable for his time. This would be better expressed by saying that historical ethnology in Polynesia to-day is no improvement on the guesswork of an untrained nineteenth-century missionary. In Père Laval's time speculations on the insoluble problem of Polynesian origins might form part of the unsystematic, haphazard observations of pre-scientific ethnography. To-day ethnologists are, or ought to be, occupied with more important problems and more profitable lines of inquiry.

As Dr. P. H. Buck remarks in his Preface, this work is a valuable addition to the very inadequate information of Beechey, Moerenhout, and other earlier writers; and as such it will be useful to the specialist. But the general reader will do better to turn to the recent works of Mead, Firth, Hogbin, and Buck himself for a more sympathetic as well as a more scientifically accurate picture of Polynesian character and culture. R. P.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

LANDSLIDES AND RELATED PHENOMENA: a study of mass-movements of soil and rock. By C. F. Stewart Sharpe. *New York: Columbia University Press* (*London: Oxford University Press*), 1938. 9½×6 *inches; xii+138 pages; illustrations.* 15*s*

It is common to think of the detail of our scenery as largely developed through the erosive action of streams, glaciers, and waves, with local embellishments due to volcanicity and crustal movement. Recently students of geomorphology have begun to give more adequate credit to the slow and less spectacular processes of creep and solifluction. Nevertheless mass movements, slow or rapid, have hitherto received less careful study than was their due.

Some years ago Eliot Blackwelder focused attention on this somewhat neglected aspect of denudation, under the title "The landslide family and its relations." Recently public interest has been aroused on the whole problem of soil conservation. The present booklet by Dr. Stewart Sharpe, of the Soil Conservation Service of the United States Department of Agriculture, attempts to systematize the study of superficial mass movements by distinguishing a gradational series ranging from stream-flow (much water, small load, low angle),

through slopewash, sheetflood, mudflow, earthflow, debris-avalanche, to landslide (little water, large load, moderate to high angle). While a logically exhaustive analysis might also include glacial action, the latter aspect of transportation is excluded in a treatment concerned primarily with denudation under temperate conditions. The various types of mass movement grade into each other, but four groups of process are separated: slow flowage, including soil-creep, solifluction, talus-creep, rock-glacier creep, and rock-creep; rapid flowage, involving earthflow, mudflow, and debris-avalanches; sliding, covering rock-slide, rockfall, and slumping; and subsidence, collapse over caves, mines, sinkholes, etc. The object of the book is to clarify ideas regarding the causes and characteristics of different types of movement. The treatment is essentially theoretical and little attempt is made to give the analysis any directly practical turn that would be of use, for instance, to the civil engineer.

The bibliography lists two hundred and seventy-five selected references under appropriate headings. It is significant that of the first fifty-two references on general principles, rock-creep and soil-creep, only four are in British publications, the latest being dated 1889; while of the next forty, dealing with solifluction and frost action, only four of the eight British contributions were written in the present century; there are no listed British references on the subject of subsidence or on the prevention of landslides. It is clear that in this country the study of mass movements has remained in a neglected position comparable to that of soil research in the earlier years of the century.

The nine pages of photographic illustrations are well chosen, two-thirds of them being by the author. Diagrams clarify differences in character between various types of processes which are ordinarily not sufficiently distinguished.

G. B. B.

BIOCLIMATICS: a science of life and climate relations. By ANDREW DELMAR HOPKINS. *Washington, D.C.: United States Department of Agriculture* (*Misc. Publn. No.* 280), 1938. 11½×9 *inches;* iv+188 *pages; diagrams and maps*

Probably the best-known bioclimatic law for temperate North America is one already stated by Hopkins: that in spring and early summer periodic events are approximately four days later for 1° lat. northward, 5° long. eastward, or 400 feet increase in altitude. In late summer and autumn conditions are reversed.

It is surprising to find how far this useful generalization is now extended. With a ruler and pencil one can cover a map of the world with isophenes, or lines rising westward and northward at the rate of 1° lat. to every 5° long. It is assumed that along these lines phenomena of life and climate should be equal across the continents at the same level and under equal influences. This, of course, is not realized in fact, but variations from astronomical and bioclimatic requirements are, it is claimed, most conveniently measured with reference to these isophenes. The bioclimatic zones of the world are re-classified with particular reference to the modifying influence of physiography instead of in terms of astronomical or isothermal concepts only. A series of tables is given, designed, in conjunction with representative thermal and phenological data, to give reliable preliminary information on combinations of zonal types to be expected in any given region.

To many people the attempt to put the bioclimatics of the whole world into a card-index system will seem rather an assumption, particularly as the greater part of the original research will be appreciated by only a few experts. However it cannot be denied that field surveys are expensive and take time, and that pro-

cedure based on bioclimatic principles is infinitely to be preferred to the costly process of trial and error. There is a quite obvious value to a system that seeks to predict the agricultural practices best suited to a region and which can supply advance information on such important subjects as control of insect pests.

It is a pity that bioclimatics, interrelated as it is with climatology, meteorology, geography, ecology, and phenology should have been presented in so formidable a manner. After wrestling with examples requiring the use of an appendix and a glossary of symbols one should not be further exhausted by sentences of 131 words punctuated only with commas. While the value of the research is amply demonstrated for North America, there will be few biologists who will be inspired to "study the essential principles of bioclimatics and endeavour to understand how they may be applied to his special subject of research."

D. H. C.

DEUTSCHE ATLANTISCHE EXPEDITION AUF DEM FORschungs- und Vermessungsschiff "Meteor" . . . 1925–1927. Wissenschaftliche Ergebnisse. Ed. by ALBERT DEFANT. Band XIV. Die meteorologischen Beobachtungen. By ERICH KUHLBRODT and JOSEPH REGER. Abschnitt A. Die Beobachtungsmethoden und das Beobachtungsmaterial. Abschnitt B. Die meteorologischen Ergebnisse. *Berlin: Walter de Gruyter & Co.*, 1938. $11\frac{1}{2} \times 9$ *inches;* xiv + 392 *pages; illustrations, maps, and diagrams. M.*30 *and* 32

The results obtained by the *Meteor* during its cruises in the Atlantic between April 1925 and May 1927 are presented in two large quarto volumes, of which the first gives details of the methods of observation of the surface meteorological elements and of the instrumental equipment, followed by tables in which are given the daily observations during the whole period at sea. The first table gives observations at 7, 14, and 21 hours of the barometric pressure in millimetres; temperature and relative humidity in the screen; temperature, relative humidity and vapour pressure obtained by the Assmann psychrometer; temperature of the surface water of the sea; wind velocity and direction; cloud types and amount; visibility; state of the sea, and sea swell. In addition, there are given for 14 hours the wet-bulb temperature and the equivalent temperature as obtained from the Assmann psychrometer. The separate journeys across the Atlantic, and the journeys out and home, are given in separate sections of this table. The second table gives, for each day at sea, hourly values of pressure, temperature of the air and of the sea, relative humidity, wind velocity and direction, visibility, and precipitation. The amount of the observational material can be gathered from the above list of the tabulated elements. The *Meteor* spent 512 days at sea, making journeys across the Atlantic in a direction roughly parallel to the circles of latitude, between 60° S. and 20° N.

The second volume gives a statistical discussion of the data. Here we find the usual tables and diagrams of the regional distribution of the elements, as found along the different courses followed by the ship. In particular, considerable attention is devoted to the variation along the courses followed across the Atlantic of the wind direction, pressure, temperature, and difference of sea and air temperature. Days having more than 20 mm. of rain are shown in a separate table. Among the most interesting results shown in the tables and diagrams are the diurnal variations of the trade winds, which show pronounced maxima of velocity at 8 hours and 22 hours. There is a small difference in the diurnal variation in the two trades.

The discussion of the diurnal variation of temperature of the air and of the sea surface is also of considerable interest. The screen temperatures show a

total range of variation of about 5° C., as also do the electrically recording thermometers, while the total range of variation measured with the Assmann psychrometer is only about half this amount. One is left in some doubt as to how much of the measured variation may be due to insolation of the instruments. The difference between the screen thermometer and the Assmann instrument is greatest at about 14 hours, which also suggests that insolation of the instruments may be an important factor in the production of the large apparent range of variation of the air temperatures observed. It is certainly of interest to compare these figures with those obtained by Johnson in the Mediterranean (see *Q. J. Roy. Met. Soc.* 55, 1927, p. 59). Using a platinum resistance element in a specially constructed anti-radiation housing, with a provision for the aspiration of the element, Johnson found a total diurnal range of variation of only 1·05° C. per day in May, 1926. The *Meteor* observations of the temperature of the sea surface showed a diurnal range of 2° C.

The diurnal range of cloudiness showed a definite main maximum at 6 hours, with a lower secondary maximum at about 18 hours. The study of clouds is also represented by a series of very beautiful photographs, some of which show striking forms.

The diurnal variation of pressure in different regions is shown in a series of tables and graphs, which are of interest in connection with the study of the change in the form of the semi-diurnal pressure wave with latitude.

A later section of the volume discusses the variations of both relative humidity and absolute humidity. The former shows a definite minimum at about 14 hours, as might be anticipated from the occurrence of the maximum temperature at about that time, but the absolute humidity in the tropics has its lowest minimum at about 4 hours, and a second minimum at about 14 hours.

From what has been said above it will be gathered that the two volumes under review are full of observational material of the greatest value. The discussion can only be regarded as preliminary, and the mass of information which these two volumes contain will provide meteorologists with food for discussion for some time to come. Of the printing and general production of the two volumes under review we need only add that they reach the same high standard as the earlier volumes in the same series. D. B.

CARTOGRAPHY

AN INTRODUCTION TO MAPWORK AND PRACTICAL GEOgraphy. By JOHN BYGOTT. Second edition. *London: University Tutorial Press*, 1938 (*first published in* 1934). $8\frac{1}{2} \times 6\frac{1}{2}$ *inches;* viii+246 *pages; illustrations and maps.* 8*s* 6*d*

This book is written to meet the requirements of upper forms of schools and first-year University classes in all branches of practical geography, and therefore covers a very wide range of topics: the rudiments of map reading and cartography, map interpretation (topographical and geological maps), the mapping of statistics (including population maps), weather maps, map projections and surveying. Its comprehensive scope makes it a useful general work of reference for schools and students of geography; but that so much ground can be covered in the space of 214 pages indicates that the text is inevitably summary and the treatment often very generalized. It seems a pity that space is also devoted to matters not strictly within the scope of the subject as generally interpreted: *e.g.* 12 pages on the evolution of land forms and principles of denudation, 6 pages on explanations of climate. Surely the student should be left to refer to larger standard texts for these subjects. As it is, the treatment here is perforce

oversimplified, sometimes dangerously so, and the space might well have been devoted to amplification of the main purpose and content of the book: map work. The text includes many diagrams and maps and a number of full-page portions of actual Ordnance Survey maps, which greatly increase its value.

A. Gt.

ECONOMIC AND HISTORICAL GEOGRAPHY

ALTGERMANIEN IM ERDKUNDEBUCH DES CLAUDIUS Ptolemäus. By Theodor Steche. *Leipzig: Curt Habitsch*, 1937. 9½×6½ *inches; 192 pages; key-maps. M.10*

In finishing his monumental work on Ptolemy, Father Josef Fischer made no claim that the study of the Alexandrine geographer was even approaching completeness but rather that he was supplying the basis for more intensive research. In the work under review we have one such intensive study, which merits careful attention, though strangely enough it contains no reference to Fischer's labours, the main dependence being placed on two earlier writers, Cuntz and Šimek, especially the former, as regards Ptolemy's work and methods in general. The careful study of Ptolemy's northern Europe carried out earlier still by the Danish scholar Gudmund Schütte seems also to be ignored, though it included the very region with which the present work is concerned. On the other hand Dr. Steche appears to be fully conversant with previous literature on ancient Germany from all points of view.

Beginning with general considerations, Dr. Steche lays stress on the need for a proper understanding of the basis of Ptolemy's geographical co-ordinates, putting in the forefront the difference to be traced between his degrees of latitude and longitude. Longitudinal distances were no doubt generally exaggerated, but it is difficult to accept the conclusion that Ptolemy actually regarded the equatorial degree of longitude as smaller than that of latitude (which is apparently the writer's view), mistakes in longitudes being intelligible enough without such an assumption. Another point stressed is the unwisdom of basing conclusions on any one text—even the best established—in view of the constant liability to errors of transcription, due to the Greek system of representing numbers, the nature of the script, the limitations of the language for precise definition of position, etc. The changes in the sound-values of the characters employed, as well as the linguistic affinities of the sources of information, are also considered.

Coming to the special subject of the memoir, Ptolemy's description and map of Germany, Dr. Steche deals first with the representation of the coasts of western and northern Europe and reaches the striking conclusion that the whole picture, while generally accurate within itself, suffers a consistent shifting of some two degrees to the north and west. This is ingeniously explained as due to the ambiguous use of the name *Sacrum Promontorium*, transferred in course of time from Cape Roca to Cape St. Vincent. By not realizing that the more southerly cape was intended in his sources of information, Ptolemy introduced an initial error which was propagated throughout the rest of the picture. This shifting of the coast-line resulted in an undue extension of the courses of the German rivers, their upper parts being laid down on information obtained by land, so that there is really a broad hiatus between these and their termination on the coast. Special attention is devoted also to the mountain system described by Ptolemy, a correct interpretation of which is a pre-requisite to the proper location and settlement of the German tribes in Ptolemy's day. This is the ultimate aim of the study, but being of less general interest outside Germany cannot be enlarged upon here.

Like Schütte, Dr. Steche is impressed with the surprising accuracy of Ptolemy's information concerning Germany, but unlike the former considers that the old geographer thought little of physical configuration, his aim being merely to supply a basis for the mapping on a plane surface. In another passage he dwells on Ptolemy's disregard of political conditions and his character of a student of Nature rather than of state-craft. Throughout the study he is at pains to put himself in Ptolemy's place and finds as a rule plausible, if not entirely convincing, explanations of his errors. It is surprising enough that, with the means at his disposal, Ptolemy should have reached the degree of accuracy attributed to him by the author. E. H.

EMPIRE OPPORTUNITIES: a survey of the possibilities of overseas settlement. Contributed by Dominions and other experts. [T. C. MACNAGHTEN and others.] *London: Blackie & Son*, 1938. 8×5½ *inches;* vi+266 *pages.* 7s 6d

This work is apparently intended as a guide book for those wishing to settle in the Dominions. It begins with a general survey of the problems of emigration and empire settlement. This is followed by more detailed accounts of the opportunities offered to settlers in the Dominions, in Southern Rhodesia, and in East Africa. These detailed accounts have each a brief bibliography and a section on "General information and statistics," which consists rather of the type of information to be found in text-books on commercial geography. The book closes with a short account of the opportunities for women settlers and a list of organizations which train and assist prospective emigrants. There is no index.

Although the authors take an optimistic view of the conditions within the countries which they describe, they are not very hopeful about any immediate resumption of immigration into them. The old days of free, or even very cheap, land are over and the settler now needs considerable capital if he means to start farming on his own. Few settlers might agree with Major Cawthorn's statement that "in Kenya as elsewhere expenditure on petrol and drinks is the factor that really determines the individual cost of living," but most settlers have a standard of living which they hope to maintain or improve in their adopted country. This is often difficult, especially on less fertile and less accessible land, despite its apparent cheapness. Nor can the emigrant hope for much governmental assistance at the present time. Such assistance has been given in the past, but it is an exaggeration to say, as Mr. Macnaghten does, that "during the nineteenth century, state-aided emigration was given a full and prolonged trial." The problems involved in the resumption of emigration on a large scale are extremely complicated, but they receive only a superficial treatment in this book. Little is said of drought and indebtedness which affect settlement in the prairie provinces of Canada, or of the native and "poor white" problems in South and East Africa (the native problem is said, for example, to be "not at present in any way a serious one" in Kenya), or of the effects of industrial development in Australia and New Zealand upon the demand for primary products.

The authors have provided much useful information and advice for prospective settlers, but the conclusion to be drawn from their accounts is a pessimistic one. Emigration is dormant during a period of recovery; it can hardly hope to revive during depression. T. S. W.

PRIMITIVE RACES OF TO-DAY. By J. W. PAGE. *London: George G. Harrap & Co.*, 1938. 9×5½ *inches;* 348 *pages; illustrations and maps.* 8s 6d

The author has undertaken a task of some magnitude, for in some 332 pages he has managed to give an account of no less than sixteen different types of

communities from all over the world, under the headings of hunters and collectors, hunters and fishers, gardeners, and herders. Moreover the book is well illustrated and contains a number of maps. It is a digest of the works of the authors given in the large and comprehensive bibliography, so that the sources of information are available for those who wish to consult the original works.

In a work of this size and scope it is obvious that Mr. Page could not deal with all the aspects of native life in the communities which he has selected, nor could any one reviewer be expected to have an intimate knowledge of all the parts of the world covered by the author. As regards the pygmies, for instance, the account is as good as can be expected, since the literature on the subject is not really very satisfactory. The reviewer would not have gone to the same authorities for an account of cultivators in equatorial Africa, but the account is good and the authorities in question are sound. During the last few years a number of important books have been written about African life, some of which are not noted by Mr. Page in his bibliography; if his work is to be up to date, then these books should be mentioned, even if the author has not found it practicable to include the subject-matter.

As a text-book this work fulfils its function; the facts are there and the matter has been dealt with objectively and competently. It is obviously the product of much labour and scholarship, though readers who prefer to learn about people rather than about things and facts may well find its contents somewhat indigestible.

E. B. H.

GENERAL

GEOGRAPHY IN SCHOOL. By JAMES FAIRGRIEVE. Fourth edition. *London: University of London Press*, 1937 (*first published in* 1926). 8×5 *inches;* x+418 *pages; illustrations and maps.* 9*s*

The fact that this work on the teaching of geography has survived eleven years and four editions, in these days of rapidly changing ideas, is a sufficient indication of its value in the eyes of teachers of the subject, for it is by no means the only book in its field. Mr. Fairgrieve is not merely an educational theorist; his book is based on thirty years' experience of geography teaching in most types of British school, and upon a long period spent in preparing university students for the teaching profession. His "confession of faith" is that "the function of geography is to train future citizens to imagine accurately the conditions of the great world stage and so help them to think sanely about political and social problems in the world around." The book consists very largely of theoretical and practical discussions, packed with useful hints to teachers on major and minor aspects of their work, on how best to encourage children to develop accurate ideas about their own and other parts of the world, only a minute fraction of which it will ever be their lot to see in reality. Amongst the main topics dealt with are the fundamentals of map work, the use of "material aids" such as atlases, globes, the epidiascope and the film, the importance of local geographical study and the planning of syllabuses, and the book concludes with a stimulating chapter entitled "Can we teach geography better?" which formed the author's Presidential Address to the Geographical Association in 1936, and which is incorporated in the book for the first time. There is a comprehensive bibliography of works in English.

Mr. Fairgrieve knows from long experience what is easy and what is difficult in teaching geography, and his book contains just those essential words of guidance which young teachers will find most helpful. He does not lay down a rigid methodology, but realizing that good teaching depends on the personality of the teacher as much as upon the matter and its presentation, suggests

guiding principles and means of avoiding errors. It is in its wealth of detail as much as in its broad pedagogic generalizations that the value of the book lies.

S. H. B.

SEEHERRSCHAFT. By JOSEF MÄRZ. DER OSTSEERAUM. By WULF SIEWERT. (Macht und Erde. Edited by K. HAUSHOFER and U. CRÄMER. Hefte 7 and 8.) *Leipzig: B. G. Teubner*, 1937 *and* 1938. 8½×6 *inches; 60 and 100 pages; maps. M.0.90 and 1.80*

This essay outlines briefly the significance of sea power and its natural foundations, before discussing the present naval situation. Seamanship is held to be a Nordic characteristic, French achievements being dismissed with a gibe and no mention being made of the Portuguese. The importance of Singapore to the British Empire, the position in the Mediterranean, the steps taken by France to secure her communications with Africa outside the Mediterranean, are among the matters treated briefly. The section on the German Navy is rather subdued, and is confined to its rôle as a protector of the coast-line. The disjointed method of treatment prevents the subject from emerging with any clearness, and the historical side is neglected.

A much more concrete example of the rôle of sea power is given in the second monograph, though in the main it is a sketch, from the modern German point of view, of the geographical features of the Baltic countries, and their relations to their historical development. Lithuania, Poland, and Russia are excluded on cultural grounds; northern Germany is included for its contribution to Baltic civilization, but with a warning against its becoming exclusively absorbed in regional politics. The themes are the necessity of both land and sea power for supremacy in the Baltic, and the predominant share, in the building up of the present national and cultural status, of the *Drang nach Osten*. The first is well illustrated by the history of the Hanseatic leagues; whether the second is a complete interpretation of history is doubtful. The discussion of the strategic position during the last war is interesting: in 1917–18 nearly 10,000,000 tons of Swedish ore crossed to Lübeck and Stettin, and this traffic depended upon the Kiel Canal and the continuance in being of the German High Seas Fleet.

G. R. C.

PASSENGER BY AIR. By RICHARD COKE. *London: John Hamilton*, [1937]. 8½×5½ *inches; 318 (incl. x) pages; illustrations. 10s 6d*

This is a most interesting and picturesque description of all the leading air routes of the world. It covers air travel from the days when the war-time bombers were pressed into service, on our cross-Channel service to Paris, to the present high-speed air routes of America. The author is obviously an enthusiastic air traveller. He has travelled extensively by commercial airliner and airship, and, being a passenger, he has had time to appreciate the wider view from the air and to describe the romance and interest of these far-flung air routes. Parts read rather like a guide-book, but there is a wealth of descriptive and historical detail which should be of great interest to all travellers.

D. F. M.

THE MONTHLY RECORD

THE FRESHWATER BIOLOGICAL ASSOCIATION

We have received from the Director, Dr. E. B. Worthington, the sixth annual report of the Freshwater Biological Association. The laboratory of the Association is at Wray Castle, Ambleside, which is held on lease from the National Trust. The report summarizes the progress of the Association's work, and indicates the lines of future progress. Its field of research is broadly the examination and explanation of the factors which control the productivity of life in fresh waters, limited by the qualification that it cannot undertake work which can equally well be carried out in University laboratories. Through the support it is receiving from interested organizations, it has been able to begin work upon two particular problems, the bacteriology of fresh waters, and the coarse fish of the British Isles.

From the point of view of water supply, an important problem is the progressive change in the production of plants and animals which takes place in reservoirs, often at a much greater rate than in natural lakes. This increase is largely controlled by the bottom deposits, and the value of an echo-sounding machine in providing useful information is stressed. During the year a bathymetric survey of Windermere by an echo-sounding machine was carried out for the Association by the Hydrographic Department of the Admiralty. Within a few weeks three hundred cross-sections, with continuous soundings, were obtained. The charts will ultimately be published by the Hydrographic Department on the scale of 6 inches to the mile. The results obtained differ only in detail from the survey published by Dr. H. R. Mill in 1895. A further advantage of this method is that the records also show the depth of the soft mud deposits lying on the hard floor of the lake, as some waves are reflected from the surface of the mud, and others from the rock below. The reliability of these results has been tested by cores of the deposits obtained by a boring apparatus. These cores may also contribute much to knowledge of the Quaternary geology of the Lake District.

DRIFT OF THE SOVIET POLAR CAMP

Notices recording the drift of the Soviet Polar Camp have already appeared in the *Journal* for November 1937 and February 1938. While the last of these was in the press, the drift was approaching its end. It had been intended to last a year, but in more southerly latitudes the speed of the floe increased dangerously; at the beginning of February it split, and though records, instruments, and stores were safely moved to a smaller floe, hydrological work had to cease, and it was judged expedient to bring the experiment to an end. Three icebreakers and a survey ship had been despatched from Murmansk and Kronstadt; and on February 19, in lat. 70° 54′ N. and long. 19° 48′ W., the four men and their instruments and records were taken off the icefloe by the *Taimyr* and the *Murman*.

The movement of the floe on which their camp was drifting provided one of the most interesting subjects for work. In the course of the 274 days, during which they drifted from lat. 89° 26′ N. and long. 78° W., the floe covered 1139 miles in a south-south-westerly direction. Allowing for the numerous zigzags, the speed of drift averaged 4·9 miles a day; but in February the average had risen to 12·3 miles a day. A preliminary examination of the observations shows that the ice has a permanent drift to the south, independent of the local

wind; the speed of this movement increased from about a mile a day near the Pole to from 5 to 7 miles a day between lats. 75° and 70°. Observations seemed to show that this drift was due not to a surface current but to the prevalence of northerly and north-westerly winds over a vast stretch creating a general flow of ice towards the Greenland Sea.

In the course of their observations on the drift of the floe, the party had occasion to study the currents in the upper layers of the water; they were also equipped for taking soundings. With the aid of a specially constructed deep-water hand-worked winch, 33 measurements were made, of which 14 were at depths of more than 3000 metres. At the start they passed over a hollow sloping to a depth of about 4395 metres in lat. 88° 41′ N. and long. 10° W.; thereafter the bottom rose unevenly. At lat. 83° 56′ N. and long. 0° 47′ E. an under-water elevation at a depth of 2380 metres was recorded. Farther south, in lat. 81° 53′ S., long. 6° W., a depth exceeding 4160 metres was obtained: the whole of the cable was paid out but bottom was not reached. The existence of these depths are of great interest in view of their proximity to Greenland. Measurements were also taken at the so-called Nansen threshold at lat. 81° S. and long. 6° 50′ W. The depth was 1420 metres, and this, it is considered, disproves the supposition that the sea bed rises considerably more than 1000 metres, thus dividing the Arctic Ocean from the Greenland Sea. Samples were taken of the oceanic silt in the deep hollow of the polar basin, and these are awaiting analysis.

Study of the currents showed that Atlantic water flowing into the Arctic Ocean between Greenland and Spitsbergen reaches the Pole and spreads extensively throughout the greater part of the polar basin. Nansen, in the drift in the *Fram*, had discovered the layer of water of Atlantic origin with positive temperatures, which underlies the comparatively thin layer of Arctic water; the Soviet expedition were able to prove its existence near the Pole and to make a series of measurements of the various layers.

In the course of the soundings, samples of plankton were collected from various depths; and in August 1937 an intensive development of microscopic seaweed was shown to take place at the end of the short polar summer, when the snow had melted from the surface of the ice and sufficient light had penetrated it. Animal plankton was brought up from 3000 metres.

During the drift gravity measurements were made at 22 points between lats. 89° and 74° S. Magnetic measurements were also made with the aid of a magnetic theodolite, and show that over the course of the drift there were no considerable anomalies.

Reference has already been made in the previous notes in the *Journal* to the meteorological observations carried out four times daily. These included temperature of the air, pressure, humidity, and direction and velocity of the wind. The rapid drift of the floe enabled the party to spend four months only in the region of the cold polar cap, but they found the weather calmer than on the borders of the Arctic Ocean. There were no very strong winds; neither was there the steady anticyclonic régime anticipated. The weather reports were communicated to the mainland daily, and proved of considerable use in forecasting.

TRANSPORT IN ICELAND

In a little pamphlet entitled 'Transport in Iceland' (published by the author, 39, Beverley Gardens, Stanmore, Middlesex, 1938. 1s), Adam Rutherford gives the first connected account in English of transport conditions in Iceland, and between Iceland and other countries. The remarkable progress which has recently been made is discussed under the following heads: railway projects;

roads and bridges; motor transport; lighthouses and harbours; sea transport; mails; air transport; administration; and tourist facilities.

Chiefly because of the great physical contrasts existing within so small an area, transport in Iceland has developed along somewhat different lines from those in any other European country. Some interesting historical notes and statistics trace the gradual opening up of the country, and a map shows the main routes now available. There is however no motorable road in the south-east from Höfn to Djúpivogur as marked on the map. B. B. R.

AN EIGHTEENTH-CENTURY TRAVELLER IN PERSIA

We have received from Mr. H. L. Rabino the following note on an eighteenth-century traveller in Persia and the Near East. Mr. Rabino has been unable to ascertain any details other than those contained in the document quoted below; students of the period may be able to throw further light on the traveller:

In a batch of old manuscripts obtained in Paris I found a paper entitled "Prospectus des Voïages d'Emmanuel Franco, originaire de Bastia, en Corse." This is a summary of a projected work in two volumes, for which, being completely ignorant of the French language, he was anxious to find an editor. The author states that he had travelled for twenty-three years in the East and had carefully recorded his observations on the Crimea, Circassia, Persia, and Turkey. The summary begins with Baghcha Serai, and continues with Astrakhan, the steppe, the Kalmucks, Derbend, where he says he visited the "palais antique d'Alexandre," Mount Ararat, Ardabil, Isfahan, Baghdad, Aleppo and its "magnifique monastère de la nation Ecopte," Damascus and Cairo. Of Mount Ararat he remarks: "C'est là où un hermite allemand nous fit voir l'Arche de Noé. J'expliquerai dans mon ouvrage par quels moïens on a conservé jusqu'à present ce monument antique." At Cairo, in order to avoid the bastinado, he became a Moslem. This no doubt gave him further opportunities of studying the country and people. After a brief survey of Smyrna and the islands of the Archipelago, he describes Constantinople and his adventures in that city. The sole date contained in the document is that of his arrival in Isfahan, 25 September 1779. From the outline it is clear that he was not boasting when he claimed to have made a special study of the customs of the countries he visited.

The projected book does not appear to have been published, and I have not been able to trace Franco's name among existing lists of travellers in Persia in the eighteenth century. My efforts to trace descendants of the author, who might be able to throw light upon his manuscript, presumably written in Italian, have also proved fruitless. M. Paul Aimé, Archivist of the Department of Corsica, informs me that no person of the name of Franco is to be found in the rolls of the inhabitants of Bastia. He suggested that Franco might be an abbreviation for Francesco. This cannot however be inferred from the name as written in the manuscript, and in any case Francesco as a surname does not appear in the rolls. M. l'abbé Zattera, librarian of Bastia, also failed to find the name Franco in the baptismal registers or archives of the city. It is possible that Franco was born in a neighbouring village, but it has proved impossible to have all the registers searched.

GEOLOGY OF THE OILFIELD BELT OF IRAN AND 'IRAQ

The bulk of "The geology of the oilfield belt of Iran and 'Iraq" (reprinted from 'The science of petroleum,' published by the Oxford University Press) is devoted to a concise statement of the stratigraphy, oil indications, and structural conditions of south-western Iran with special reference to the discovered oil

fields. It is illustrated by sketch-maps, sections, and photographs. Geographers will be most interested in the introduction, for there the author correlates the Zagros Ranges as an arc of the Dinaric limb of the Alpine mountain system. They run from Mosul to Bandar 'Abbas, a distance of about 1000 miles with mountains rising up to 15,000 feet in height upon their north-eastern side. In them Palaeozoic and Mesozoic rocks are packed and folded. Neogene deposits stand folded and sculptured to form the foothills on their south-western side, and beyond them extends the broad plain of 'Iraq and south-western Iran. It is a synclinal structure filled with alluvial deposits and is slowly subsiding as it fills up with deposits from the Tigris, Euphrates, and Karun.

Dr. Lees will not expect universal agreement regarding the fate of the Zagros Ranges east of Bandar 'Abbas where a syntaxis occurs; nor will all agree with him when he writes that the first orogenic movement of importance occurred in the upper Cretaceous, because Jurassic–lower Cretaceous mountain building movement[1] seems to have been demonstrated. After a lapse of some years, a few lines are inserted to deal with the salt-plugs of the area and controversies connected with them are indicated. One of the illustrations is a telling photograph of a great salt dome with a salt glacier.

For the first time a candid discussion of the Iranian oil fields has been published with frank acknowledgement of the many difficulties attending the search for fresh fields in this region. The bewildering disharmony between the surface beds and the smooth massive limestone-reservoir folds is obvious from the sections in Fig. 4. The paper closes with a description of the reservoir rocks and deals with their porosity, permeability, and jointing. J. V. H.

CIRQUE FORMATION

In an earlier paper, published in this *Journal* in November 1936 (pp. 431–434), Mr. W. V. Lewis discussed the development of incipient corries in south-east Iceland, and referred their initiation to the process of nivation in much the same way as Matthes had envisaged. He extended the principle to apply for snow patches large enough to insulate the ground beneath them; for in such cases, melt-water trickling under the snow and freezing in cold weather would be the main agent of erosion: it would effect rigorous frost shattering, and provide a lubricant for the downward movement of the weathered material. The rôle of melt-water in less youthful stages of corrie or cirque development is now emphasized in a paper which Mr. Lewis has recently published, entitled "A melt-water hypothesis of cirque formation" (*Geological Magazine*, vol. LXXXV, June 1938, pp. 249–266).

The conception that a cirque wall recedes by the shattering freeze and thaw action of melt-water percolating down it was referred to by Mr. Odell in connection with the cwm glaciers of north-east Greenland (*Geogr. J.*, 90 (1937) 246–250). Mr. Lewis reinforces this idea by bringing to its support field evidence from a number of Scottish and Welsh cirques and by making a fuller statement of the geomorphological implications of the hypothesis. In particular, he shows how it accounts for the almost universal shattering of the headwalls down to their base. In many instances in Britain these headwalls are between 1000 and 2000 feet in height. He also points out how his hypothesis explains the sharp *L*-shaped angle where the headwall meets the cirque. Mr. Lewis has himself observed melt-water seeping down the headwall of cirques in Iceland and hopes to verify this process by further study in the Alps this summer.

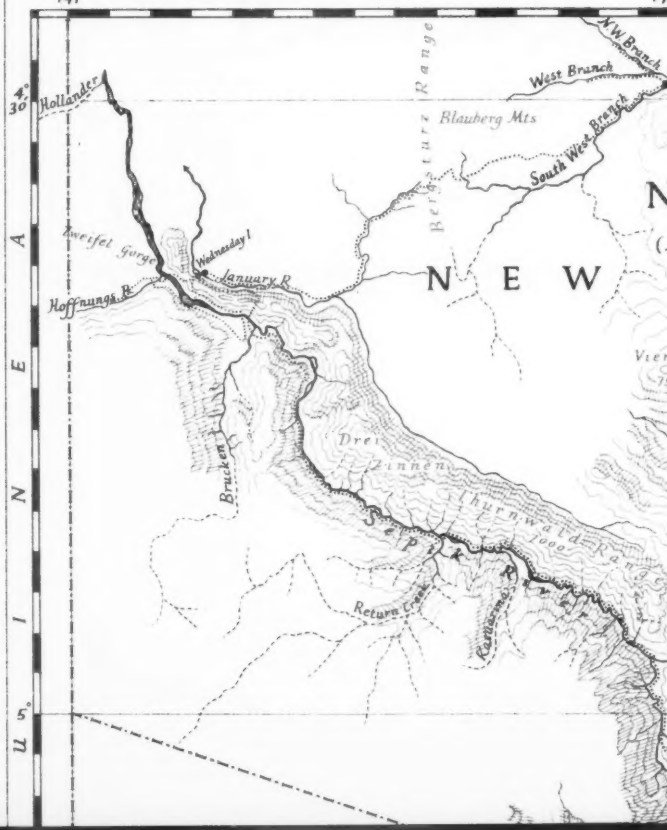
The bergschrund hypothesis, discredited in the form in which Mr. Willard

[1] *Geol. Ges. in Wien*, xxix (1936) p. 293.

Johnson originally formulated it, is really the parent of the melt-water hypothesis. It is principally a matter of the melt-water percolating all the way down the cirque wall to its foot, instead of being limited in its action only to that part of the rock face in contact with the bergschrund.

At the end of his paper, Mr. Lewis draws attention to the fact that most of the British cirques he examined face in approximately the same direction, and he suggests that this reflects the importance of shade in cirque development. Indeed orientation with respect to shade is probably a more significant factor in the development of many glacial land forms than is generally recognized.

W. L. S. F.


141°
4°
30'
5°
Hollander
Zweifel Gorge
Wednesday I.
January R.
Hoffnungs R.
Bruckenberg
Drei Zinnen
Sepik R.
Return Creek
Carlsmith R.
Thurnwald Range
Bewani Mts
Blauberg Mts
South West Branch
West Branch
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141°30'
Branch
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4°
30'
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(Mianmin)
South Branch
G U I N E A
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Stolle
9000
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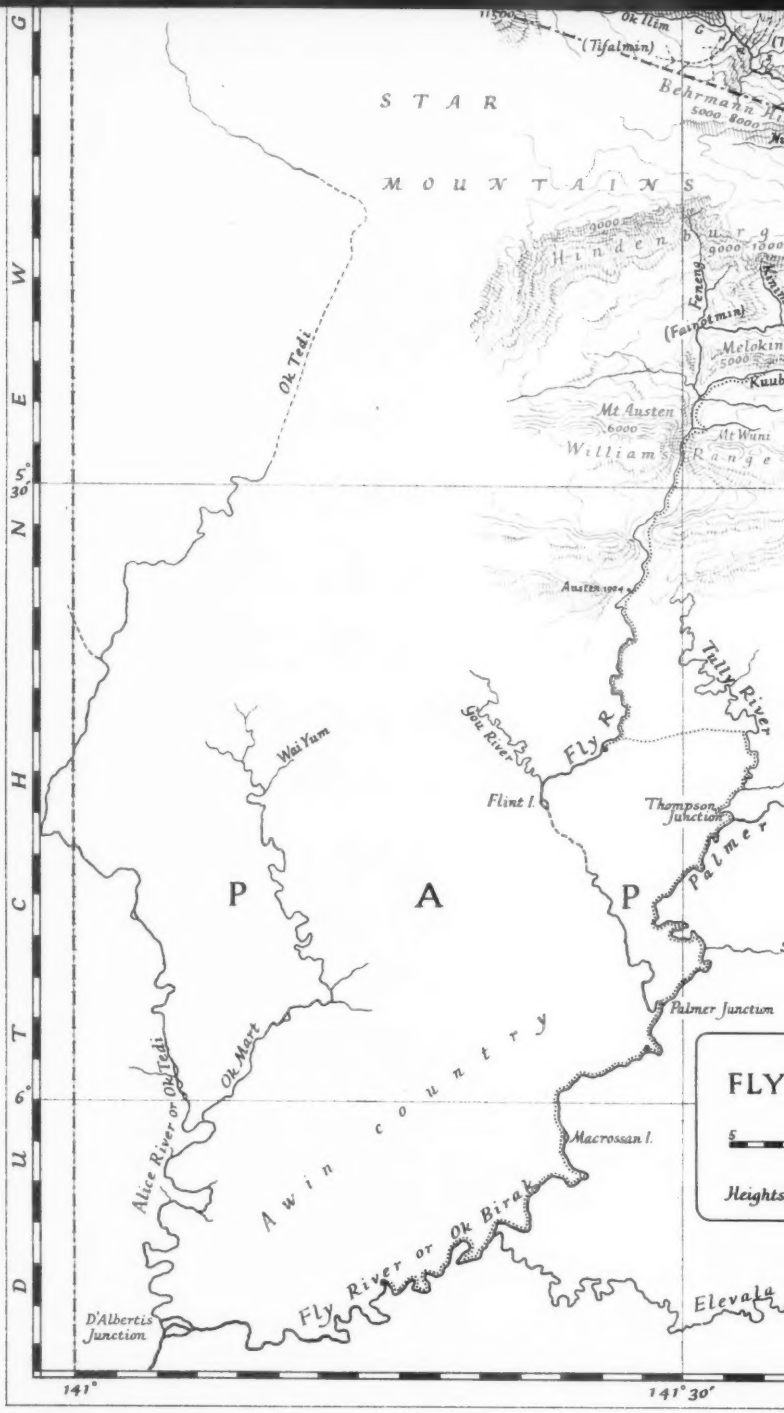

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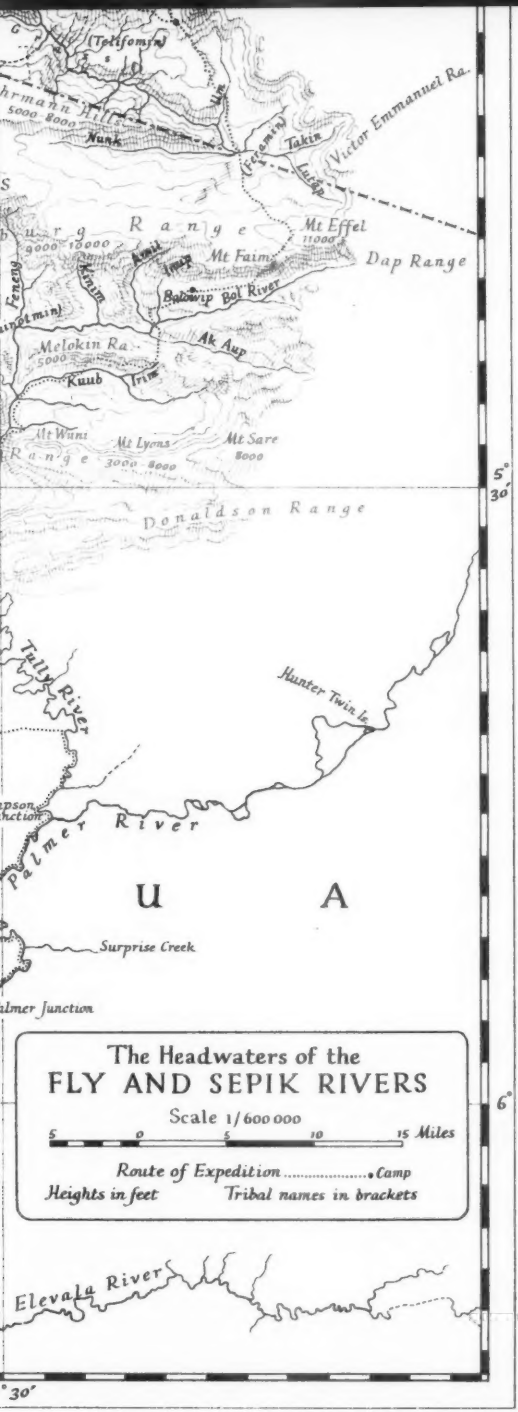

NEW GUINEA
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